Apprenticeship and Industry Training

Power System Electrician

Apprenticeship Course Outline

4609 (2009)

Alberta

Apprenticeship and Industry Training

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Power System Electrician
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COURSE OUTLINE

Apprenticeship

Apprenticeship is post-secondary education with a difference. It helps ensure Alberta has a steady supply of highly skilled employees, the foundation of our economy's future health and competitiveness.

Apprentices in more than 50 trades and crafts spend between one and four years learning their trade - 80% of the time on the job under the supervision of a certified journeyman or qualified tradesperson. The balance of the program is technical training in the theory, skills and technologies of their trade.

To become certified journeymen apprentices must learn theory and skills, and they must pass examinations. Requirements for certification—including the content and delivery of technical training—are developed and updated by the Alberta Apprenticeship and Industry Training Board (the Board) and a network of local and provincial industry committees.

The graduate of the Power System Electrician apprenticeship training is a journeyman who will be able to:

- responsibly do all work tasks expected of a journeyman.
- supervise, train and coach apprentices.
- use and maintain hand and power tools to the standards of competency and safety required in the trade.
- read and interpret drawing, plans and specifications and layout and develop projects according to specifications.
- coordinate power system work with other trades employed in the industry in both construction and maintenance.
- perform assigned tasks in accordance with quality and production standards required in industry.

Apprenticeship and Industry Training System

Industry-Driven

Alberta's apprenticeship and industry training system is an industry-driven system that ensures a highly skilled, internationally competitive workforce in more than 50 designated trades and occupations. This workforce supports the economic progress of Alberta and its competitive role in the global market. Industry (employers and employees) establishes training and certification standards and provides direction to the system through an industry committee network and the Alberta Apprenticeship and Industry Training Board. The Alberta government provides the legislative framework and administrative support for the apprenticeship and industry training system.

Alberta Apprenticeship and Industry Training Board

The Alberta Apprenticeship and Industry Training Board provides a leadership role in developing Alberta's highly skilled and trained workforce. The board's primary responsibility is to establish the standards and requirements for training and certification in programs under the Apprenticeship and Industry Training Act. The board also provides advice to the Minister of Advanced Education and Technology on the needs of Alberta's labour market for skilled and trained workers, and the designation of trades and occupations.

The thirteen-member board consists of a chair, eight members representing trades and four members representing other industries. There are equal numbers of employer and employee representatives.

Industry Committee Network

Alberta's apprenticeship and industry training system relies on a network of industry committees, including local and provincial apprenticeship committees in the designated trades, and occupational committees in the designated occupations. The network also includes other committees such as provisional committees that are established before the designation of a new trade or occupation comes into effect. All trade committees are composed of equal numbers of employer and employee representatives. The industry committee network is the foundation of Alberta's apprenticeship and industry training system.

Local Apprenticeship Committees (LAC)

Wherever there is activity in a trade, the board can set up a local apprenticeship committee. The board appoints equal numbers of employee and employer representatives for terms of up to three years. The committee appoints a member as presiding officer. Local apprenticeship committees:

- monitor apprenticeship programs and the progress of apprentices in their trade, at the local level
- make recommendations to their trade's provincial apprenticeship committee (PAC) about apprenticeship and certification in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- make recommendations to the board about the appointment of members to their trade's PAC
- help settle certain kinds of disagreements between apprentices and their employers
- carry out functions assigned by their trade's PAC or the board

Provincial Apprenticeship Committees (PAC)

The board establishes a provincial apprenticeship committee for each trade. It appoints an equal number of employer and employee representatives, and, on the PAC's recommendation, a presiding officer - each for a maximum of two terms of up to three years. Most PACs have nine members but can have as many as twenty-one. Provincial apprenticeship committees:

- make recommendations to the board about:
    - standards and requirements for training and certification in their trade
    - courses and examinations in their trade
    - apprenticeship and certification
    - designation of trades and occupations
    - regulations and orders under the Apprenticeship and Industry Training Act
- monitor the activities of local apprenticeship committees in their trade
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in their trade
- promote apprenticeship programs and training and the pursuit of careers in their trade
- consult with other committees under the Apprenticeship and Industry Training Act about apprenticeship programs, training and certification and facilitate cooperation between different trades and occupations
- consult with organizations, associations and people who have an interest in their trade and with employers and employees in their trade
- may participate in resolving certain disagreements between employers and employees
- carry out functions assigned by the board

Power System Electrician PAC Members at the Time of Publication

Mr. S. Schlachter	Calgary	Presiding Officer
Mr. B. McNeill	Stony Plain	Employer
Mr. R. Pierce	Calgary	Employer
Mr. E Weeks	Sherwood Park	Employer
Mr. M. Marshall	Spruce Grove	Employer
Mr. T. Miller	Calgary	Employee
Mr. J. Debnam	Calgary	Employee
Mr. M. Koppel	Calgary	Employee
Mr. R. Carrell	Slave Lake	Employee

Alberta Government

Alberta Advanced Education and Technology works with industry, employer and employee organizations and technical training providers to:

- facilitate industry's development and maintenance of training and certification standards
- provide registration and counselling services to apprentices and employers
- coordinate technical training in collaboration with training providers
- certify apprentices and others who meet industry standards

Technical Institutes and Colleges

The technical institutes and colleges are key participants in Alberta's apprenticeship and industry training system. They work with the board, industry committees and Alberta Advanced Education and Technology to enhance access and responsiveness to industry needs through the delivery of the technical training component of apprenticeship programs. They develop lesson plans from the course outlines established by industry and provide technical training to apprentices.

Apprenticeship Safety

Safe working procedures and conditions, incident/injury prevention, and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of government, employers, employees, apprentices and the public. Therefore, it is imperative that all parties are aware of circumstances that may lead to injury or harm.

Safe learning experiences and healthy environments can be created by controlling the variables and behaviours that may contribute to or cause an incident or injury. By practicing a safe and healthy attitude, everyone can enjoy the benefit of an incident and injury free environment.

Alberta Apprenticeship and Industry Training Board Safety Policy

The Alberta Apprenticeship and Industry Training Board fully supports safe learning and working environments and encourages the teaching of proper safety procedures both within trade specific training and in the workplace.

Trade specific safety training is an integral component of technical training, while ongoing or general non-trade specific safety training remains the responsibility of the employer and the employee as required under workplace health and safety legislation.

Workplace Responsibilities

The employer is responsible for:

- training employees and apprentices in the safe use and operation of equipment
- providing and maintaining safety equipment, protective devices and clothing
- enforcing safe working procedures
- providing safeguards for machinery, equipment and tools
- observing all accident prevention regulations

The employee and apprentice are responsible for:

- working in accordance with the safety regulations pertaining to the job environment
- working in such a way as not to endanger themselves, fellow employees or apprentices

Workplace Health and Safety

A tradesperson is often exposed to more hazards than any other person in the work force and therefore should be familiar with and apply the Occupational Health and Safety Act, Regulations and Code when dealing with personal safety and the special safety rules that apply to all daily tasks.

Workplace Health and Safety (Alberta Employment, Immigration and Industry) conducts periodic inspections of workplaces to ensure that safety regulations for industry are being observed.

Additional information is available at www.worksafely.org

Technical Training

Apprenticeship technical training is delivered by the technical institutes and many colleges in the public post-secondary system throughout Alberta. The colleges and institutes are committed to delivering the technical training component of Alberta apprenticeship programs in a safe, efficient and effective manner. All training providers place great emphasis on safe technical practices that complement safe workplace practices and help to develop a skilled, safe workforce.

The Power System Electrician trade has common first and second period with the electrician trade and the following institutions deliver Electrician apprenticeship technical training where apprentices can take the first two periods of technical training and the third and fourth periods can be taken at NAIT Main Campus:

Northern Alberta Institute of Technology (Main Campus)	Northern Alberta Institute of Technology (Grande Prairie Campus)
Lakeland College	Lethbridge College
Keyano College	Medicine Hat College (Brooks Campus)
Southern Alberta Institute of Technology	Red Deer College
Northern Lakes College	Portage College

Procedures for Recommending Revisions to the Course Outline

Advanced Education and Technology has prepared this course outline in partnership with the Power System Electrician Provincial Apprenticeship Committee.

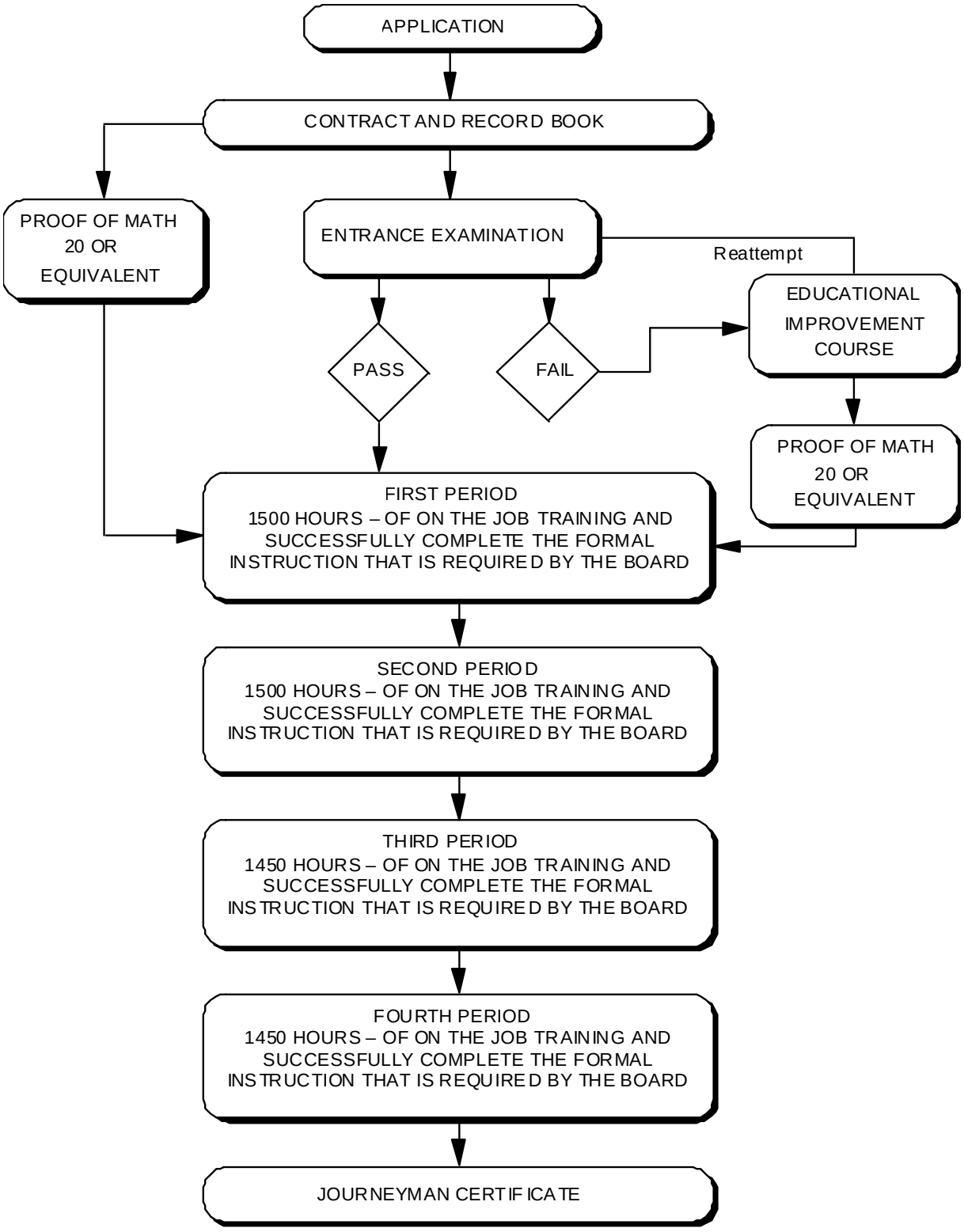
This course outline was approved on March 20, 2009 by the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. The valuable input provided by representatives of industry and the institutions that provide the technical training is acknowledged.

Any concerned individual or group in the province of Alberta may make recommendations for change by writing to:

Power System Electrician Provincial Apprenticeship Committee
c/o Industry Programs and Standards
Apprenticeship and Industry Training
Advanced Education and Technology
10th floor, Commerce Place
10155 102 Street NW
Edmonton AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used. Recommendations for change will be placed on the agenda for regular meetings of the Power System Electrician Provincial Apprenticeship Committee.

Apprenticeship Route toward Certification



Power System Electrician Training Profile
FIRST PERIOD
(8 Weeks 30 Hours per Week – Total of 240 Hours)

SECTION ONE

CIRCUIT FUNDAMENTALS
80 HOURS

A	B	C
Basic Mathematics 10 Hours	Composition of Matter 4 Hours	Current, Voltage, and Resistance 10 Hours
D	**E**	**F**
Characteristics of Conductors 6 Hours	Series Resistive Circuits 8 Hours	Parallel Resistive Circuits 8 Hours
G	**H**	**I**
Series-Parallel Resistive Circuits 12 Hours	Work, Energy, Power and Efficiency 10 Hours	Edison 3-Wire Distribution Systems 12 Hours

SECTION TWO

EMF SOURCES
26 HOURS

A	B	C
Methods of Producing EMF 4 Hours	Cells and Batteries 8 Hours	Magnetism 4 Hours
D	**E**	
Electromagnetism and Electromagnetic Induction 6 Hours	Generators 4 Hours	

SECTION THREE

LAB FUNDAMENTALS
69 HOURS

A	B	C
Safety 6 Hours	Meters 4 Hours	Conductors 6 Hours
D	**E**	**F**
Splicing and Terminating (Low Voltage) 3 Hours	Resistors 2 Hours	Switching Circuits 10 Hours
G	**H**	**I**
Basic Circuits Using Buzzers and Chimes 6 Hours	Relays and Controls 12 Hours	Low Voltage Switching 10 Hours
J		
Residential Alarm Systems and Smoke Alarms 10 Hours		

SECTION FOUR

CANADIAN ELECTRICAL CODE PART I AND BLUEPRINTS
65 HOURS

A	B	C
Introduction to Code 4 Hours	General Rules – Section 2 4 Hours	Conductor Material and Sizes 4 Hours
D	**E**	**F**
Service and Grounding Requirements 6 Hours	Service Feeders and Branch Circuits 6 Hours	Wiring Methods 8 Hours
G	**H**	**I**
Installation of Electrical Equipment 4 Hours	Installation of Lighting Equipment 4 Hours	Lighting 6 Hours

J	K	L
Data Cabling 7 Hours	Class 1 and Class 2 Circuits 2 Hours	Electrical Apprenticeship Training Program Orientation 2 Hours
M	**N**	**O**
Orthographic Projection / Diagrams 2 Hours	Dimensioning and Scaling / Print and Diagram Nomenclature / Construction Drawings 2 Hours	Print Reading / Applied Drawings 4 Hours

SECOND PERIOD
(8 Weeks 30 Hours per Week – Total of 240 Hours)

SECTION ONE

ALTERNATING CURRENT (ac) CIRCUIT PROPERTIES
36 HOURS

A	B	C
Review of Math Skills 4 Hours	Review of First Period Theory 2 Hours	Fundamentals of Alternating Current 6 Hours
D	**E**	**F**
Introduction to ac Circuits 6 Hours	Inductance and Inductive Reactance 6 Hours	Capacitance and Capacitive Reactance 6 Hours
G		
Power Relationships 6 Hours		

SECTION TWO

RLC CIRCUITS
74 HOURS

A	B	C
Introduction to Series ac Circuits 10 Hours	Series Resistive-Reactive Circuits 12 Hours	Series RLC Circuits 14 Hours
D	**E**	**F**
Introduction to Parallel ac Circuits 10 Hours	Parallel RLC Circuits 14 Hours	Power Factor Correction 14 Hours

SECTION THREE

CANADIAN ELECTRICAL CODE PART I / PLANS AND DIAGRAMS
55 HOURS

A	B	C
Introduction to Second Period Canadian Electrical Code 2 Hours	Service Conductor Ampacity for a Single Dwelling 4 Hours	Services and Service Equipment for a Single Dwelling 2 Hours
D	**E**	**F**
Feeder and Branch Distribution Requirements for a Single Dwelling 3 Hours	Grounding Requirements for a Single Dwelling 3 Hours	Service Ampacity for Apartments and Similar Buildings 6 Hours
G	**H**	**I**
Service Protection and Controls for Apartments and Similar Buildings 2 Hours	Electric Discharge Lighting, Emergency Systems and Unit Equipment 2 Hours	Overview of Hazardous Locations - Section 18 3 Hours
J	**K**	**L**
Class 1 Wiring Methods 4 Hours	Class 1 Locations – Section 20 2 Hours	Installations in Class II Locations 2 Hours
M	**N**	**O**
Installations in Class III Locations 2 Hours	Corrosive and Wet Locations - Section 22 4 Hours	Electrical Installations in Patient Care Areas – Section 24 2 Hours

P

Capacitor Bank Installations — 2 Hours

Q

Diagrams — 2 Hours

R

Specifications — 4 Hours

S

Drawings and Plans — 4 Hours

SECTION FOUR

HEATING AND COOLING CONTROLS

33 HOURS

A

Principles of Automatic Heating and Cooling Controls — 8 Hours

B

Temperature Sensing and Control Devices — 3 Hours

C

Basic Gas-Fired Forced-Air Heating Systems — 8 Hours

D

Mid/High-Efficiency / Gas-Fired / Forced-Air Heating Systems — 4 Hours

E

Basic Hot Water Heating Systems — 2 Hours

F

Cooling Systems — 4 Hours

G

HVAC Rooftop Units — 4 Hours

SECTION FIVE

MAGNETIC CONTROL AND SWITCHING CIRCUITS

42 HOURS

A

Drawings — 2 Hours

B

Construction of Control Relays and Contactors Operations of Relays — 6 Hours

C

Timers and Smart Relays — 4 Hours

D

Protection Devices (General) Protection Devices (Motor Circuits) — 4 Hours

E

Construction of Magnetic Motor Starters Overload Devices — 6 Hours

F

Single Motor Control/ Pilot Devices and Symbols — 6 Hours

G

Diagram Conversion — 6 Hours

H

Reversing Magnetic Starters — 8 Hours

THIRD PERIOD
(10 weeks 30 Hours per Week – Total of 300 Hours)

SECTION ONE

THREE PHASE
46 HOURS

A	B	C
Electrical Circuits Theory 6 Hours	Three Phase Systems (General) 3 Hours	Analytical Geometry / j-Notation 4 Hours
D	**E**	**F**
Three Phase Wye Circuits (Part 1) 6 Hours	Three Phase Wye Circuits (Part 2) 4 Hours	Three Phase Delta Connection 10 Hours
G	**H**	
Three Phase Power Measurement 8 Hours	Power Factor Correction 5 Hours	

SECTION TWO

MACHINE THEORY
70 HOURS

A	B	C
Transformers 4 Hours	Transformer Ratio, Polarity and Multiple Winding 12 Hours	Transformers Losses, Impedance Voltage and Paralleling 10 Hours
D	**E**	**F**
Three Phase Transformers 20 Hours	Single Phase Motors 6 Hours	Three Phase Induction Motors 14 Hours
G		
dc Motors 4 Hours		

SECTION THREE

INTRODUCTION TO SUBSTATION THEORY
114 HOURS

A	B	C
Power Transformers (Part 1) 8 Hours	Power Transformers (Part 2) 16 Hours	Autotransformers 10 Hours
D	**E**	**F**
Voltage Regulators 10 Hours	Power Circuit Breakers (Part 1) 14 Hours	Power Circuit Breakers (Part 2) 10 Hours
G	**H**	**I**
Transmission Line 3 Hours	Lightning &Surge Protection 3 Hours	Capacitors & Capacitor Banks 4 Hours
J	**K**	**L**
Reactors 1 Hour	Generators 8 Hours	Paralleling Generators 10 Hours
M	**N**	**O**
Synchronous Motors 1 Hour	Substation Batteries 4 Hours	Grounding 10 Hours
P		
Insulators 2 Hours		

SECTION FOUR

ELECTRONICS THEORY

40 HOURS

A	B	C
Electronics Introduction 10 Hours	PN Junction Diode 4 Hours	Rectifiers 10 Hours

D	D	E	F
Filters 6 Hours		Silicon Controlled Rectifier (SCR) 2 Hours	Applications of Diodes and Rectifiers 8 Hours

SECTION FIVE

PRINT READING

30 HOURS

A	B
Applied Print Interpretation 16 Hours	Troubleshooting Electrical Circuits 14 Hours

FOURTH PERIOD
(10 Weeks 30 Hours per Week – Total of 300 Hours)

SECTION ONE

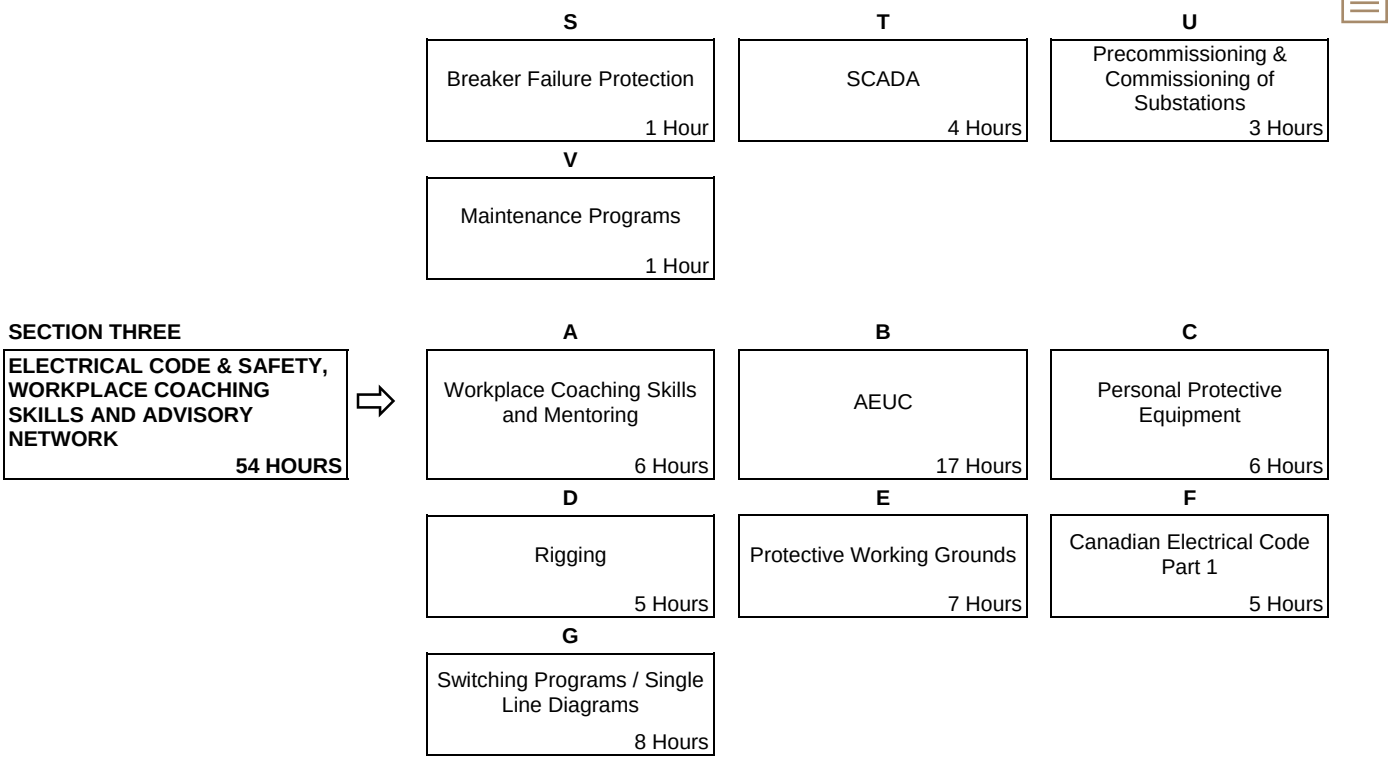
METERING THEORY
100 HOURS

A	B	C
Instruments 7 Hours	Watt-Hour Meters 6 Hours	Single Phase Meter Connections 14 Hours
D	**E**	**F**
Three Phase Meter Connections 14 Hours	Demand Meters 10 Hours	Polyphase Meters 16 Hours
G	**H**	**I**
Metering Transducers 6 Hours	Meter Totalizing & Recording 12 Hours	Safety in Changing Meters 4 Hours
J	**K**	**L**
Telemetering and Automated Metering Infrastructure 4 Hours	Regulatory Agencies 4 Hours	Detection & Prevention of Energy Theft 3 Hours

SECTION TWO

ADVANCED SUBSTATION THEORY
146 HOURS

A	B	C
Potential Transformers 8 Hours	Current Transformers 8 Hours	Power Systems 2 Hours
D	**E**	**F**
Bus Configuration 3 Hours	Switching Equipment 5 Hours	System Fault Current 20 Hours
G	**H**	**I**
Symmetrical Components 6 Hours	Relaying 2 Hours	Relaying Systems 5 Hours
J	**K**	**L**
Overcurrent Protection 24 Hours	Directional Protection 14 Hours	Differential Protection 10 Hours
M	**N**	**O**
Impedance Protection 5 Hours	Reclosing Relays 6 Hours	Synchronising Check Relay 1 Hour
P	**Q**	**R**
Frequency Protection 1 Hour	Network Protection 1 Hour	Microprocessor and Logic Relay Functions 16 Hours



NOTE: The hours stated are for guidance and should be adhered to as closely as possible. However, adjustments must be made for rate of apprentice learning, statutory holidays, registration and examinations for the training establishment and Apprenticeship and Industry Training

FIRST PERIOD TECHNICAL TRAINING
POWER SYSTEM ELECTRICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: ..... CIRCUIT FUNDAMENTALS ..... 80 HOURS

A. Basic Mathematics ..... 10 Hours

Outcome: ***Solve trade-related problems using basic mathematical skills.***

1. Recognize basic arithmetic symbols.
2. Add whole, decimal and fractional numbers.
3. Subtract whole, decimal and fractional numbers.
4. Multiply whole, decimal and fractional numbers.
5. Divide whole, decimal and fractional numbers.
6. State the correct sequence for arithmetical operations and solve equations which use brackets.
7. Demonstrate the math skill required for transposition of equations in relation to Ohm's Law.

B. Composition of Matter ..... 4 Hours

Outcome: ***Describe the relationship between atomic structure and electron flow.***

1. Describe the basic composition of matter.
2. Describe the basic structure of the atom.

C. Current, Voltage, and Resistance ..... 10 Hours

Outcome: ***Define voltage, current and resistance and predict how changing the value of any one of them affects the circuit.***

1. Describe an electric current.
2. Describe voltage.
3. Describe resistance and state and apply Ohm's law.
4. Connect and verify relationship between voltage, current and resistance according to Ohm's law.

D. Characteristics of Conductors ..... 6 Hours

Outcome: ***Describe conductors, semiconductors and insulators and calculate the resistance of conductors. Describe the composition of fibre optic cables and their proper handling and installation.***

1. Demonstrate the math skills required to calculate the resistance of a conductor of specific dimensions.
2. Describe the factors affecting resistance.
3. Calculate the resistance of a conductor of specific dimensions.
4. Describe the electrical properties of materials.
5. Describe fibre optic systems.

E. Series Resistive Circuits .....8 Hours

Outcome: ***Connect and analyze a series resistive circuit and analyze the relationships between current, resistance and voltage.***

1. Define a series circuit and calculate current in a series circuit.
2. State the formula for total resistance and calculate resistance in a series circuit.
3. State and apply Kirchhoff's voltage law to a series circuit.
4. Define the terms ratio and direct proportion and perform calculations using both.
5. State the relationship between the resistive values of components and their voltage drops and solve problems using the voltage divider rule.
6. Determine the voltage drop across a closed-or-open-circuit component in a series circuit.
7. Connect and verify Kirchhoff's current and voltage laws in a series resistive circuit.

F. Parallel Resistive Circuits .....8 Hours

Outcome: ***Connect and analyze the voltage, current and resistance characteristics of a parallel circuit.***

1. Define a parallel circuit.
2. Calculate the total resistance of a parallel circuit using the appropriate formulas.
3. State and apply Kirchhoff's current law to a parallel circuit.
4. Describe the effects of open circuits on a parallel circuit.
5. Use the current divider principle to calculate branch currents.
6. Connect and verify Kirchhoff's current laws in a parallel resistive circuit.

G. Series-Parallel Resistive Circuits ..... 12 Hours

Outcome: ***Connect and analyze a series-parallel resistive circuit.***

1. Identify resistors that are in series.
2. Identify resistors that are in parallel.
3. Calculate the total resistance of a series-parallel circuit.
4. Apply Kirchhoff's current law.
5. Apply Kirchhoff's voltage law.
6. Solve problems involving series-parallel circuits.
7. Connect and verify the relationship of current, voltage and resistance in each part of a series/parallel circuit.

H. Work, Energy, Power and Efficiency..... 10 Hours

Outcome: ***Describe the terms mass, work, force, energy, and power; describe how they are interrelated mechanically and electrically, and calculate the efficiency of simple circuits.***

1. Describe mass, weight and force.
2. Describe work, energy and power.
3. Describe electrical relationships of work, energy and power.
4. Calculate efficiency, voltage drop and line loss.
5. Connect and verify the power formulae.

I. Edison 3-Wire Distribution Systems ..... 12 Hours

Outcome: Connect and analyze an Edison 3-wire system.

1. Identify an Edison 3-wire system.
2. Analyze an Edison 3-wire system.
3. Describe and calculate the effects of a high resistance or broken neutral in an Edison 3-wire system.
4. Connect and verify the effects of a high resistance or broken neutral in an Edison 3-wire system.

SECTION TWO: .....EMF SOURCES.....26 HOURS

A. Methods of Producing EMF.....4 Hours

Outcome: Describe methods of producing EMF.

1. Explain the production of EMF by using chemicals.
2. Explain the production of EMF by using heat.
3. Explain the production of EMF by using pressure.
4. Explain the production of EMF by using light.
5. Explain the production of EMF by using magnetism.
6. Explain the production of EMF by using electrostatics.

B. Cells and Batteries.....8 Hours

Outcome: Describe some common batteries, their care and handling, and recharging precautions.

1. Define the basic terminology of cells.
2. Describe the construction and operation of a basic primary cell.
3. Describe the construction and operation of three types of lead-acid batteries.
4. Describe the construction and operation of a nickel-cadmium battery.
5. Describe the construction and operation of a lithium battery.
6. Describe the hazards and precautions to be observed when charging batteries.
7. Describe the three common battery performance ratings.
8. Calculate the effects of battery internal resistance.

C. Magnetism.....4 Hours

Outcome: Describe a magnetic material and define the terms used to express the characteristics of magnetic materials.

1. Describe the properties of magnetic materials.
2. Define the terminology related to magnetism.

D. Electromagnetism and Electromagnetic Induction .....6 Hours

Outcome: Describe electromagnetism and electromagnetic induction.

1. Describe electromagnetism and basic design considerations for electromagnetic devices.
2. Describe how an induced voltage is generated.
3. Describe the process of electromagnetic induction.

E. Generators .....4 Hours

Outcome: Describe the voltage and current characteristics of an ac and a dc generator.

1. Describe the basic construction of a generator.
2. State how a generator produces a voltage and identify the factors affecting its value.
3. State how a generated voltage can be connected to supply alternating current or direct current to a load.

SECTION THREE:.....LAB FUNDAMENTALS.....69 HOURS

A. Safety.....6 Hours

Outcome: Demonstrate knowledge of safe work practices, safety procedures and responsibility for safety in the workplace.

1. Describe the workplace safety programs in Alberta and safety procedures relating to the power system electrician trade.
2. Identify and describe the safe use of common hand tools and equipment related to the power system electrician trade.
3. Identify and describe the safe use of common power and specialty tools related to the power system electrician trade.
4. Identify and describe lockout procedures.

B. Meters.....4 Hours

Outcome: Describe proper use, care and safety precautions for various electrical meters.

1. State the applications of the various meters.
2. List the precautions that must be observed when using meters.
3. Interpret the readings of analog meters.
4. Interpret the readings of digital meters.
5. Recognize the connections for various meters.
6. Demonstrate proper range selection and connections of voltmeter, ammeter, ohmmeter and megger.

C. Conductors .....6 Hours

Outcome: Describe basic forms and types of conductors, understand the methods used to identify conductor size, and predict the effects of conductor size on voltage drop in a circuit.

1. State the common types of conductor materials.
2. List the common forms of conductors.
3. Calculate the cross-sectional area of conductors.
4. Determine the AWG wire size with a wire gauge.
5. Calculate the approximate voltage drop due to conductor resistance.

D. Splicing and Terminating (Low Voltage).....3 Hours

Outcome: Describe how to make effective splices, taps and terminations.

1. List and describe four classes of terminations or connections used in the electrical trade.
2. Describe the proper method for stripping conductors and insulating splices.
3. Describe three common wire connections.
4. Describe the techniques used for mechanical and compression splices and terminations.
5. Describe the problems specific to aluminum conductor splices and terminations.

E. Resistors .....2 Hours

Outcome: Identify various resistors and interpret their ratings.

1. List two categories of resistors and describe their construction.
2. Explain the methods used to determine the ratings of fixed resistors.
3. Use a colour code chart to determine the resistance of a resistor.

F. Switching Circuits ..... 10 Hours

Outcome: Describe specific circuit switching arrangements by creating schematic drawing and wiring diagrams and demonstrating their connections in a lab.

1. Draw symbols that are commonly used in schematic and wiring diagrams.
2. Connect and verify the switching arrangement of various types of switches.
3. List applications of various types of switches.
4. Draw schematic and wiring diagrams for typical lighting circuits and demonstrate their connection.

G. Basic Circuits Using Buzzers and Chimes .....6 Hours

Outcome: Design, draw and connect a variety of series and parallel circuits.

1. Determine when to connect pushbuttons and buzzers in series and parallel for various operations and demonstrate their connection.
2. Describe how to connect a set of door chimes and how to add an additional set if required and demonstrate the connection of circuits using buzzers and chimes.

H. Relays and Controls..... 12 Hours

Outcome: Connect and analyze control circuits that use relays.

1. Define specific terms that are used when referring to control circuits.
2. Identify the parts of a relay.
3. Describe the operating principle of a relay.
4. Draw the symbols that are commonly used in control circuits.
5. Draw schematic and wiring diagrams using a relay.
6. Demonstrate the connection of circuits using relays.

I. Low Voltage Switching ..... 10 Hours

Outcome: Connect and analyze low voltage switching circuits.

1. Describe the basic concepts of a low voltage switching system.

2. State the advantages of low voltage switching.
3. Describe the operation of a low voltage switching system.
4. Demonstrate the connection of low voltage circuits.

J. Residential Alarm Systems and Smoke Alarms..... 10 Hours

Outcome: ***Describe the operation of, and troubleshoot residential alarm systems and smoke alarms.***

1. Identify various types of sensing and alarm devices used in residential alarm systems.
2. Describe the operation of a basic residential alarm system.
3. Identify the function and applications of residential smoke alarms and carbon monoxide alarms.
4. Connect, analyze and troubleshoot a residential alarm system.
5. Describe the operation of a basic fire alarm system.

SECTION FOUR:.....CANADIAN ELECTRICAL CODE PART I AND BLUEPRINTS.....65 HOURS

A. Introduction to Code .....4 Hours

Outcome: ***Understand why and how the Canadian Electrical Code Part I, and the Alberta Electrical STANDATA are used to provide minimum standards for electrical installations in the province. Find information within the Canadian Electrical Code Part I, and know who is responsible for electrical installations.***

1. Explain the purpose of the Canadian Electrical Code Part I.
2. Describe the procedures for the acceptance of the Canadian Electrical Code by the provinces and the local authorities.
3. Describe the function of the electrical STANDATA.
4. Describe the organizational layout of the CEC.
5. Locate specific information in the CEC using a variety of methods.
6. Identify those responsible for an electrical installation.

B. General Rules – Section 2 .....4 Hours

Outcome: ***Understand the following terms as they apply within Section 2 of the CEC; administrative, safety, maintenance, and enclosure requirements for an electrical installation.***

1. Define the specific terms from Section 2 that apply to the first period code program.
2. Become familiar with the administrative rules in Section 2.
3. List the technical requirements described in Section 2.

C. Conductor Material and Sizes .....4 Hours

Outcome: ***Determine size, insulation type and insulation colour required for a conductor, based upon its condition of use.***

1. Define specific terms from Section 4, that apply to the first period code program.
2. Apply specific rules of Section 4 to determine conductor sizes, with reference to the appropriate tables and appendices.
3. Determine the allowable ampacity of a conductor given load current and conditions of use.
4. Describe the conditions for use of flexible cords and equipment wire and be able to determine their allowable ampacity.
5. Recognize neutral conductors and determine their size.
6. Recall the CEC standards for conductor colours.

D. Service and Grounding Requirements.....6 Hours

Outcome: ***Describe the components, installation methods and proper grounding of overhead and underground consumer's services to a single dwelling.***

1. Define specific terms from Section 6 that apply to a residential occupancy.
2. Describe the wiring methods used for the installation of overhead services.
3. Describe the wiring methods used for the installation of underground services.
4. List the requirements for service equipment in a single dwelling.
5. Define specific terms from Section 10 that apply to a single dwelling.
6. Indicate the various points for grounding and bonding of a consumer service and determine the size of these conductors.

E. Service Feeders and Branch Circuits .....6 Hours

Outcome: ***Determine the loading on services, feeders and branch circuits for single dwellings.***

1. Define specific terms from Section 8 that apply to a residential occupancy.
2. Determine the minimum ampacity of service or feeder conductors supplying a single dwelling.
3. Determine the minimum required number of branch circuit positions for a single dwelling.
4. Determine the ampacity requirements for branch circuit conductors and ampere ratings of overcurrent devices applicable to a single dwelling.

F. Wiring Methods.....8 Hours

Outcome: ***Define and describe appropriate wiring methods for common installations.***

1. Define specific terms from Section 12 that apply to a residential occupancy.
2. Demonstrate an understanding of the General Requirements sub-section in Section 12.
3. Demonstrate an understanding of the Conductors, General, sub-section in Section 12.
4. Describe the conditions for use of exposed wiring located outdoors.
5. Describe the conditions for use of non-metallic sheathed cable.
6. Describe the conditions for use of armoured and mineral-insulated cable.
7. Describe the conditions for use of raceways in general.
8. Describe the conditions for use of specific raceways.

9. Describe the installation of boxes, cabinets and outlets.

G. Installation of Electrical Equipment .....4 Hours

Outcome: ***Describe the procedures for selecting receptacles and designing branch circuits for a residential occupancy and for domestic water heating and cooking appliances.***
State the requirements pertaining to storage batteries.

1. Define specific terms from Section 26 that apply to the first period code program.
2. Apply specific rules of Section 26 that deal with the electrical installations in battery rooms.
3. List the information required when selecting a receptacle for a specific application.
4. Determine the branch circuit requirements, number and location of receptacles required for areas (other than kitchens) of a residential occupancy in general and specifically, a single dwelling.
5. Describe the types of areas that require GFCIs and AFCIs and explain the operation of a GFCI and an AFCI.
6. Determine the branch circuits required, the number and type of receptacles required and the location of each for a kitchen.
7. Determine where the disconnecting means for a furnace must be installed.

H. Installation of Lighting Equipment .....4 Hours

Outcome: ***Describe the wiring techniques involved with lighting installations and the terminology associated with lighting systems.***

1. Define specific terms from Section 30 that apply to the first period code program.
2. Become familiar with the general requirements for interior lighting equipment.
3. Describe the factors identified in Section 30, which relate to the location of lighting equipment.
4. Describe the factors identified in Section 30, which relate to the installation of lighting equipment.
5. Describe the methods of wiring various types of lighting equipment.
6. Describe the bonding requirements of lighting equipment.
7. Recall the ratings and control methods of lampholders.

I. Lighting .....6 Hours

Outcome: ***Select, install and maintain luminaries based upon the user's lighting needs.***

1. Define specific terms that are used in the lighting industry.
2. Describe the different types of electric lighting sources.
3. Describe the theory of operation of fluorescent and HID lamps.
4. Describe the types, purpose and basic operation of ballasts for electric discharge lighting lamps.
5. Compare the efficiencies and light outputs of various light sources.
6. Describe the restrictions on lamp interchangeability and the advantages and disadvantages of different maintenance regimes.

J. Data Cabling.....7 Hours

Outcome: ***Explain installation considerations and troubleshooting for data cabling systems in residential and commercial buildings.***

1. Describe the basic considerations for data cable installations.
2. Differentiate between data cable types and characteristics.

3. Describe typical data cabling system topographies and characteristics.
4. Describe installation practices for copper data cabling.
5. Describe installation practices for optical fibre cabling.
6. Explain procedures for testing and troubleshooting data cabling installations.

K. Class 1 and Class 2 Circuits .....2 Hours

Outcome: ***Identify Class 1 and Class 2 circuits and describe their CEC requirements.***

1. Define the terms from Section 16 that apply to the second period code program and list the Section 16 topics.
2. Determine the requirements for Class 1 and Class 2 circuits.
3. Identify the Class 2 circuits in a typical single dwelling.

L. Power System Electrician Apprenticeship Training Program Orientation.....2 Hours

Outcome: ***Understand the role of the tradespeople, employers, Local Apprenticeship Committees, the Provincial Apprenticeship Committee and Alberta Apprenticeship and Industry Training in the development and maintenance of the power system electrician trade in Alberta.***

1. Describe the apprenticeship training system in Alberta.
2. Study the training profile of the power system electrician apprenticeship in Alberta.
3. Describe the power system electrician program outline learning outcomes and objectives.
4. Describe the responsibilities for the Contract of Apprenticeship by the apprentice, employer and Alberta Apprenticeship and Industry Training.
5. Describe a variety of employment opportunities for power system electricians.
6. Become familiar with the contents of the apprenticeship training record book.

M. Orthographic Projection / Diagrams .....2 Hours

Outcome: ***Identify the various views of a three-dimensional object and obtain information from each one of these views.***
Understand and identify block diagrams, wiring diagrams and schematic drawings.

1. Differentiate between the basic views of objects using orthographic projection.
2. Relate basic orthographic projections to views of a building.
3. Identify the lines commonly found on a blueprint.
4. Distinguish between a block diagram and a wiring diagram.
5. Read and interpret electrical schematic drawings.

N. Dimensioning and Scaling / Print and Diagram Nomenclature / Construction Drawings .....2 Hours

Outcome: ***Read and interpret information from a drawing or print.***
Identify and interpret commonly used electrical symbols, abbreviations and terms.
List the different types of drawings and their uses in a set of construction drawings.

1. Read and interpret dimensions from a drawing or print.
2. Use a scale to determine dimensions from a drawing.
3. Identify commonly used electrical symbols.

4. Interpret common abbreviations used on prints and drawings.
5. Interpret technical terms used on prints and drawings.
6. List the different types of drawings and their uses in a set of construction drawings.
7. Describe the disciplines and types of drawings used in a set of construction drawings.

O. Print Reading / Applied Drawings .....4 Hours

Outcome: ***Interpret plan of a simple residential electrical installation.***
Interpret applied drawings of a simple residential electrical installation.

1. Extract information from a print.
2. Interpret a drawing of an overhead service for a single-family dwelling.
3. Interpret a drawing of an underground service for a single-family dwelling.
4. Interpret a partial floor plan of a typical residential electrical installation and do a material estimate.
5. Calculate the main service requirements for a single-family dwelling.

SECOND PERIOD TECHNICAL TRAINING
POWER SYSTEM ELECTRICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE:..... ALTERNATING CURRENT (ac) CIRCUIT PROPERTIES..... 36 HOURS

A. Review of Math Skills ..... 4 Hours

Outcome: ***Perform basic trade related calculations in a variety of problems.***

1. Perform arithmetic operations in the correct sequence.
2. Transpose an equation to make any stated term the subject.
3. Determine the squares or square roots of mathematical expressions.
4. Convert numbers to and from scientific notation.
5. Perform calculations involving SI prefixes.

B. Review of First Period Theory ..... 2 Hours

Outcome: ***Describe basic electrical concepts and demonstrate their relationships with calculations in a variety of circuits.***

1. Describe the relationship between resistance, current and voltage.
2. Perform power calculations for a circuit, given any three of the following: resistance, current, voltage or power.
3. Solve problems involving series resistive circuits.
4. Solve problems involving parallel resistive circuits.
5. Solve problems for circuits containing combinations of series and parallel components.
6. Use Kirchhoff's law to solve basic Edison 3-wire distribution circuits.

C. Fundamentals of Alternating Current ..... 6 Hours

Outcome: ***Describe the fundamental characteristics of ac circuits.***

1. Explain the generation of an ac sine wave.
2. Determine the output frequency of an ac generator.
3. Calculate standard ac sine wave values.
4. Demonstrate the relationship between sine waves and phasor diagrams.
5. List the factors affecting impedance in an ac circuit.

D. Introduction to ac Circuits ..... 6 Hours

Outcome: ***Understand and explain the current-limiting effects of resistance, inductance and capacitance in an ac circuit, and apply the mathematics necessary to deal with the information in this topic.***

1. Compare the three circuit properties: resistance, inductance and capacitance, with respect to their current limiting effects.
2. Explain the effects of ac on the resistance of a circuit.
3. Use the Pythagorean Theorem to solve right triangles.
4. Use trigonometric functions to solve right triangles.
5. Solve problems involving the addition of phasors.

E. Inductance and Inductive Reactance..... 6 Hours

Outcome: ***Apply the concepts of inductance and induction to dc and ac circuits.***

1. Describe a basic inductor (coil).
2. Define and describe inductance and the factors which affect it.
3. Describe induction and its effects.
4. Describe the effects of an inductor in a dc circuit.
5. Describe the effects of an inductor in an ac circuit.
6. Analyze an ac inductive circuit.
7. Describe the power relationships in an inductive circuit.
8. Connect and analyze circuits containing inductance.

F. Capacitance and Capacitive Reactance ..... 6 Hours

Outcome: ***Apply the concepts of capacitors and describe their use in dc and ac circuits.***

1. Define capacitance and describe the construction of a basic capacitor.
2. Describe dielectric strength and state the unit of measurement for electric charge.
3. Calculate the value for the time constant in a dc resistor-capacitor circuit.
4. Analyze an ac capacitive circuit.
5. Describe the power relationships in a capacitive circuit.
6. Describe capacitor types and applications.
7. Connect and analyze the existence of capacitive reactance in capacitive circuits and the effects of discharge rate when resistance is changed.

G. Power Relationships..... 6 Hours

Outcome: ***Calculate power, reactive power and apparent power in ac circuits containing R, XL, and XC.***

1. Differentiate between reactive power due to inductance and reactive power due to capacitance.
2. Determine the power, apparent power, reactive power and power factor angle in an ac circuit.

SECTION TWO: .....RLC CIRCUITS..... 74 HOURS

A. Introduction to Series ac Circuits .....10 Hours

Outcome: ***Describe how resistors, inductors and capacitors affect an ac circuit when they are connected in series.***

1. Analyze an ac circuit containing resistors connected in series.
2. Analyze an ac circuit containing inductors connected in series.
3. Analyze an ac circuit containing capacitors connected in series.

B. Series Resistive-Reactive Circuits.....12 Hours

Outcome: ***Connect and analyze series circuits that contain resistance and reactance.***

1. Analyze a circuit containing resistance and inductive reactance connected in series.
2. Describe the characteristics of a coil.
3. Solve problems involving a resistor and an inductor connected in series.
4. Solve problems involving a resistor and a coil connected in series.
5. Analyze a circuit containing a resistor and a capacitor connected in series.
6. Solve problems involving a resistor and a capacitor connected in series.

C. Series RLC Circuits .....14 Hours

Outcome: ***Connect and analyze series RLC circuits to solve for unknown circuit values and describe applications of this type of circuit.***

1. Analyze a circuit containing resistance, inductive reactance and capacitive reactance connected in series.
2. Explain the practical characteristics of series RLC circuits.
3. Solve problems involving a coil and capacitor connected in series.
4. Solve problems involving a resistor, a coil and a capacitor connected in series.

D. Introduction to Parallel ac Circuits .....10 Hours

Outcome: ***Describe how resistors, inductors and capacitors affect an ac circuit when they are connected in parallel.***

1. Analyze an ac circuit containing resistors connected in parallel.
2. Analyze an ac circuit containing inductors connected in parallel.
3. Analyze an ac circuit containing capacitors connected in parallel.

E. Parallel RLC Circuits .....14 Hours

Outcome: ***Connect and analyze ac parallel circuits that contain resistance, inductance and capacitance.***

1. Analyze a circuit containing resistance, inductive reactance and capacitive reactance connected in parallel.
2. Solve problems involving a heater connected in parallel with a motor.
3. Solve problems involving motors connected in parallel.

F. Power Factor Correction ..... 14 Hours

Outcome: ***Connect and analyze power factor correction on a system that has capacitance connected in parallel to an inductive load.***

1. Analyze a circuit that has a capacitive load in parallel with a motor.
2. State the reasons for and list the methods of maintaining a high power factor in an electrical plant.
3. Calculate the kvar rating of a capacitor bank to correct the circuit power factor using the power method.
4. Calculate the kvar rating of a capacitor bank to correct the circuit power factor using the current method.

SECTION THREE: .. CANADIAN ELECTRICAL CODE - PART I / PLANS AND DIAGRAMS ..... 55 HOURS

A. Introduction to Second Period Canadian Electrical Code ..... 2 Hours

Outcome: ***Recall terms and concepts learned in your first period code studies.***

1. Demonstrate the ability to apply rules from first period code.

B. Service Conductor Ampacity for a Single Dwelling ..... 4 Hours

Outcome: ***Calculate the minimum ampacity of conductors to single dwellings.***

1. Define the specific terms from Section 8 that apply to the second period code program and list the Section 8 topics.
2. Determine the calculated current for the service conductors supplying a single dwelling.
3. Determine the minimum ampacity for the service conductors supplying a single dwelling.
4. Determine the minimum AWG size of conductors and the trade size of conduit required for the service conductors supplying a single dwelling.

C. Services and Service Equipment for a Single Dwelling ..... 2 Hours

Outcome: ***State the requirements of a service for a single dwelling.***

1. Define the terms from Section 6 that apply to the second period code program and list the Section 6 subtopics.
2. Determine the requirements for metering equipment for a single dwelling.
3. Determine the requirements for service protection and control equipment for a single dwelling.
4. Determine the requirements for overhead service equipment and conductors.
5. Determine the requirements for underground service equipment and conductors.

D. Feeder and Branch Distribution Requirements for a Single Dwelling ..... 3 Hours

Outcome: ***Determine the branch circuit and feeder requirements for a single dwelling.***

1. Determine the requirements for a single dwelling panelboard.
2. Determine the requirements for typical single dwelling branch circuit conductors and overcurrent devices.

E. Grounding Requirements for a Single Dwelling ..... 3 Hours

Outcome: ***Determine the grounding and bonding requirements for a single dwelling.***

1. Define the terms from Section 10 applicable to second period code.

2. Determine the requirements for grounding and bonding in a single dwelling.

F. Service Ampacity for Apartments and Similar Buildings ..... 6 Hours

Outcome: ***Determine the service, feeder and branch circuit requirements of an apartment building.***

1. Calculate the minimum ampacity required for a feeder conductor to a dwelling unit in an apartment complex.
2. Determine the demand load on an apartment house or public panelboard feeder conductor.
3. Determine the demand load on a parking lot panelboard feeder conductor.
4. Calculate the minimum ampacity required for the main service conductors in an apartment complex.
5. Determine the required size of a raceway when conductors of different sizes are installed.

G. Service Protection and Control for Apartments and Similar Buildings ..... 2 Hours

Outcome: ***Determine the requirements for equipment protection, control, grounding and bonding for apartments and similar buildings.***

1. Determine the requirements for service protection and control equipment for apartments and similar buildings.
2. Determine the requirements for grounding and bonding of apartments and similar buildings.

H. Electric Discharge Lighting, Emergency Systems and Unit Equipment ..... 2 Hours

Outcome: ***Determine the requirements for the installation of electric discharge lighting, emergency systems and unit equipment.***

1. Determine the requirements for the installation of electric discharge lighting.
2. Determine the requirements for the installation of emergency systems and unit equipment.

I. Overview of Hazardous Locations - Section 18 ..... 3 Hours

Outcome: ***Describe the classification of hazardous locations and the general rules that apply to these locations.***

1. Define the specific terms from Section 18 that apply to the second period code program and list the Section 18 topics.
2. Interpret the general rules regarding installation in hazardous locations.

J. Class I Wiring Methods ..... 4 Hours

Outcome: ***Describe the installation requirements for Class I locations.***

1. Determine the requirements of an electrical installation in a Class I Zone 0 location.
2. Determine the requirements of an electrical installation in a Class I Zone 1 location.
3. Determine the requirements of an electrical installation in a Class I Zone 2 location.

K. Class I Locations - Section 20 ..... 2 Hours

Outcome: ***Recognize installations in which you could encounter Class I hazardous locations and understand specific wiring requirements that apply to each area.***

1. Define the specific terms from Section 20 that apply to the second period code program and list the Section 20 topics.

2. Determine the requirements for wiring and equipment in dispensing or refuelling stations for gasoline, propane and natural gas.
3. Determine the requirements for wiring and equipment in commercial garages.
4. Determine the requirements for wiring and equipment in residential storage garages.
5. Determine the requirements for wiring and equipment in bulk storage plants.
6. Determine the requirements for wiring and equipment in finishing process areas.
7. Determine the requirements for wiring and equipment in aircraft hangers.

L. Installations in Class II Locations ..... 2 Hours

Outcome: ***Describe the various electrical requirements for a Class II location.***

1. Determine the requirements for an electrical installation in a Class II, Division 1 location.
2. Determine the requirements for an electrical installation in a Class II, Division 2 location.

M. Installations in Class III Locations ..... 2 Hours

Outcome: ***Determine the requirements for an electrical installation in a Class III location.***

1. Determine the requirements for an electrical installation in a Class III location.

N. Corrosive and Wet Locations - Section 22 ..... 4 Hours

Outcome: ***Describe acceptable electrical installation requirements in Category 1 and 2 locations.***

1. Define the specific terms from Section 22 that apply to the second period code program and list the Section 22 subtopics.
2. Determine the requirements for electrical equipment in a Category 1 and Category 2 location.
3. Determine the requirements for electrical wiring in a Category 1 and Category 2 location.

O. Electrical Installations in Patient Care Areas – Section 24 ..... 2 Hours

Outcome: ***Determine the requirements for wiring and equipment in the specially defined areas of patient care facilities.***

1. Define the specific terms from Section 24 that apply to the second period code program and list the Section 24 topics.
2. Determine the requirements for wiring and equipment in patient care areas.
3. Determine the requirements for isolated systems in patient care areas.
4. Determine the requirements for essential electrical systems in patient care areas.

P. Capacitor Bank Installations ..... 2 Hours

Outcome: ***Determine the conductor sizes and overcurrent ratings for capacitor branch circuits and feeders and the location and ratings of any disconnecting means that are used.***

1. Determine the conductor sizes for various capacitor loads.
2. Determine the rating of the overcurrent protection required for capacitor loads.
3. Determine the requirements for capacitor discharge circuits.
4. Determine the location and current rating of capacitor disconnecting means.

Q. Diagrams ..... 2 Hours

Outcome: ***Read and interpret electrical drawings and schematic diagrams.***

1. Identify symbols that are commonly used in electrical drawings.
2. Interpret terms used in electrical drawings.
3. Interpret one-line diagrams.
4. Interpret schematic diagrams.
5. Describe the sequence of operation using a schematic diagram.

R. Specifications ..... 4 Hours

Outcome: ***Acquire a working knowledge of specifications.***

1. State the purpose of specifications.
2. Describe the organization of specifications.
3. Extract specific information from specifications.

S. Drawings and Plans ..... 4 Hours

Outcome: ***Read and interpret a set of building drawings.***

1. List and describe the divisions of prints.
2. List and describe the different views and schedules that are typically found in prints.
3. Extract specific information from the prints in general.
4. Extract specific information from a set of prints and drawings.

SECTION FOUR: ..... HEATING AND COOLING CONTROLS ..... 33 HOURS

A. Principles of Automatic Heating and Cooling Controls ..... 8 Hours

Outcome: ***Describe the basic principles for automatic controls for heating and cooling systems.***

1. Outline the basic requirements of heating and cooling systems.
2. Describe the components of a basic forced-air heating system.
3. Interpret basic electrical diagrams used to show the function of a heating or cooling control system.
4. State code requirements relating to the electrical installation of heating and cooling systems.

B. Temperature Sensing and Control Devices ..... 3 Hours

Outcome: ***Explain the operation of temperature sensing and control devices.***

1. Differentiate between the operating characteristics of various temperature-sensing devices.
2. Outline the use and application of various temperature-sensing devices used in heating and cooling systems.
3. Explain how thermostats are used in heating and cooling systems.

C. Basic Gas-Fired Forced-Air Heating Systems ..... 8 Hours

Outcome: ***Connect and troubleshoot basic 24 V and 120 V gas-fired, forced-air heating systems.***

1. Identify the components used in a basic gas-fired, forced-air heating system.

2. Describe the purpose and application of a thermocouple in a basic gas-fired, forced-air heating system.
3. Confirm proper thermocouple operation including open and closed circuit tests.
4. Describe the operation of a domestic heating system using a 24 V control circuit.
5. Connect a 24V control heating system and observe its operation.
6. Describe the operation of a unit heater using a 120 V control circuit.
7. Describe the installation and operation of a fan interlock system on a residential forced air heating system.

D. Mid/High-Efficiency Gas-Fired Forced-Air Heating Systems ..... 4 Hours

Outcome: Connect and troubleshoot mid-efficiency, gas-fired, forced-air heating systems.

1. Identify the components that make up a mid-efficiency, gas-fired, forced-air heating system.
2. Describe the operation of and troubleshoot a mid-efficiency, gas-fired, forced-air heating system.
3. Describe the operation of and troubleshoot a high-efficiency, gas-fired, forced-air heating system.
4. Describe the purpose of and application of auxiliary equipment used with gas-fired, forced-air heating systems.
5. Connect and observe the operation of a direct spark ignition system and a mid-efficiency gas-fired furnace.

E. Basic Hot Water Heating Systems ..... 2 Hours

Outcome: Connect and troubleshoot basic hot water heating systems.

1. Describe the operation of a basic hot water heating system.
2. Identify the purpose and application of the components of a hot water heating system.
3. Analyze and troubleshoot the operation of a hot water heating system.

F. Cooling Systems ..... 4 Hours

Outcome: Explain the operation of and troubleshoot basic heating and cooling systems.

1. Identify the components used in a typical cooling system.
2. Describe the operation of a typical cooling system.
3. Identify the requirements for combining a basic cooling system with an existing forced-air heating system.
4. Connect and observe the operation of a combined heating and cooling system.

G. HVAC Rooftop Units ..... 4 Hours

Outcome: Troubleshoot a basic commercial heating and cooling control circuit for an HVAC unit.

1. Describe the components of a typical HVAC unit.
2. Describe the operation of a typical HVAC unit.
3. Differentiate among the applications of thermostats.
4. Describe procedures for troubleshooting a rooftop HVAC unit.
5. Connect and observe the operation of a roof top HVAC unit.

SECTION FIVE: ..... MAGNETIC CONTROL AND SWITCHING CIRCUITS ..... 42 HOURS

A. Drawings ..... 2 Hours

Outcome: ***Identify and interpret the four basic types of electrical control drawings.***

1. Interpret the four basic types of electrical control drawings.
2. Interpret the symbols used on schematic drawings and describe the sequence of operation of a control circuit by reading the schematic diagram.

B. Construction of Control Relays and Contactors / Operation of Relays ..... 6 Hours

Outcome: ***Identify and analyze the basic components of a relay or contactor. Describe relay operating characteristics, interpret relay nameplate information and recognize the types of relays that are available.***

1. Identify the three main parts of a relay.
2. Describe the purpose of laminations and shading coils in relays and contactors.
3. Name the three different materials used for constructing relay contacts and identify the applications, advantages and disadvantages of each.
4. Describe the action of electrical contacts when the relay coil is energized and describe the problems that could arise due to incorrect contact spring tension.
5. State the advantages of double break or bridge contacts.
6. Describe the operation of a relay.
7. Interpret nameplate information and relay terminal connections.
8. Recognize and describe several common types of relays.
9. Connect and observe correct relay and contactor operation.

C. Timers and Smart Relays ..... 4 Hours

Outcome: ***Describe the need for and requirements of timers and smart relays.***

1. Describe timers and basic timing functions.
2. Describe smart relays and basic timing functions.

D. Protection Devices (General) / Protective Devices (Motor Circuits) ..... 4 Hours

Outcome: ***Describe the need for and requirements of circuit overcurrent protection. Select control and protective devices for a motor branch circuit.***

1. State two basic requirements of all distribution circuits.
2. Describe two devices used for protecting electrical equipment.
3. Identify the factors that determine short circuit currents.
4. Describe the basic disconnection and control requirements for a motor branch circuit.
5. Describe the two basic protection requirements for a motor branch circuit.
6. List the factors that determine the required ampere rating of control and protective devices in a motor branch circuit.

E. Construction of Magnetic Motor Starters / Overload Devices ..... 6 Hours

Outcome: ***Describe the parts of a magnetic motor starter, understand basic starter selection criteria and recognize basic bench tests that can be performed on a starter. Describe, select and set an overload device.***

1. Describe the parts of a magnetic motor starter.
2. Describe the criteria for determining the suitability of a starter for a specific application.
3. Recognize the ohmmeter readings that determine the operational condition of a starter.
4. State the reasons for providing overload devices for motors.
5. Summarize the requirements of CEC rules regarding motor overload devices.
6. Describe the operation and types of overload devices used for motor overload protection.

F. Single Motor Control / Pilot Devices and Symbols ..... 6 Hours

Outcome: ***Describe basic magnetic motor starter control circuits. Describe basic types of motor control circuits, list the causes of single-phasing and describe procedures for troubleshooting motor control circuits. Explain the terms maintained and momentary as they apply to pilot devices and describe the operation of an automatic device.***

1. Identify the three sections of a basic stop/start circuit.
2. Describe the behaviour of a control circuit when interlock contacts are placed in each of the three sections.
3. Identify the type of pushbuttons (NO or NC) used for stopping and starting and demonstrate how they would be connected for multiple station operation.
4. Differentiate between low voltage release and low voltage protection and state practical applications for each of the two types of control circuit.
5. List three conditions that could cause the single-phasing of a three phase motor and demonstrate how a pilot light could be connected to indicate a motor running condition.
6. Determine the cause of a malfunction in a control circuit.
7. Describe the difference between maintained and momentary types of pilot devices and list examples.
8. Describe the basic operation of automatic pilot devices and list examples.
9. Connect and demonstrate the operation of the following motor controllers:
   a) single motor control from a single station – 2-wire control
   b) single motor stop/start control from a single station – 3-wire control
   c) single motor control from two stop/start stations
   d) float switches and other pilot devices

G. Diagram Conversion ..... 6 Hours

Outcome: ***Convert wiring diagrams to schematic diagrams and schematic diagrams to wiring diagrams.***

1. Describe a method by which a wiring diagram may be converted to a schematic diagram.
2. Explain how the electrical sequence of components in a drawing may affect the number of wires in a conduit.

H. Reversing Magnetic Starters ..... 8 Hours

Outcome: ***Describe the operation and components of a reversing magnetic motor starter.***

1. Describe the operation of a reversing magnetic motor starter.
2. State the purpose of the mechanical interlocks on a reversing motor magnetic.
3. State the purpose of the electrical interlocks on a reversing motor magnetic.
4. Identify the terminal numbers for the two sets of holding contacts on a reversing motor magnetic.
5. Identify the seven sections of the control circuit that can be used for the placement of interlock contacts.
6. Connect and demonstrate the operation of the following forward reversing motor controllers:
   a) forward / reverse single station
   b) forward / reverse push button interlock
   C) forward / reverse with limit switches

THIRD PERIOD TECHNICAL TRAINING
POWER SYSTEM ELECTRICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: .....THREE PHASE..... 46 HOURS

A. Electrical Circuits Theory.....6 Hours

Outcome: ***Describe basic resistive electrical circuits.***

1. Demonstrate the math skills required to analyze basic electrical circuits.
2. Define various electrical terms.
3. Describe and analyze series and parallel resistive circuits.
4. Use Kirchhoff's law to solve basic Edison 3-wire distribution circuits.

B. Three Phase Systems (General) .....3 Hours

Outcome: ***Describe a three phase electrical system and its difference from a single phase system.***

1. Explain the advantages of three phase power.
2. Explain the generation of three phase power.
3. Explain double subscript notation used on phasor drawings.
4. Explain phase sequence and rotation.
5. Operate phase sequence indicator.
6. Verify phase reversal on a three phase motor.

C. Analytical Geometry / j-Notation.....4 Hours

Outcome: ***Solve electrical problems utilizing analytical geometry and j notation.***

1. Locate a point in the correct quadrant when given its polar or rectangular co-ordinates.
2. Convert from polar to rectangular form and vice-versa.
3. Explain the meaning of the j-operator.
4. Properly locate a phasor on the horizontal or vertical axes following repeated multiplication by the j-operator in both clockwise and counter clockwise directions.
5. Solve electrical phasor problems with the j-operator.

D. Three Phase Wye Circuits (Part 1).....6 Hours

Outcome: ***Describe the characteristics of Three Phase wye circuits.***

1. Describe the voltage and current relationships for balanced and unbalanced circuits.
2. Draw a phasor diagram for balanced and unbalanced circuits.
3. Calculate the neutral current for unbalanced circuits.

4. Calculate the power factors for balanced and unbalanced circuits.
5. Measure voltage, current and phase angle in balanced and unbalanced three phase four-wire circuit.
6. Measure neutral current for a three phase four-wire circuit.

E. Three Phase Wye Circuits (Part 2).....4 Hours

Outcome: Describe the characteristics of Three Phase wye circuits.

1. Calculate the true power consumed for balanced and unbalanced circuits.
2. Calculate the reactive power consumed for balanced and unbalanced circuits.
3. Calculate the apparent power consumed for balanced and unbalanced circuits.
4. Draw a power triangle for balanced and unbalanced circuits.

F. Three Phase Delta Connection .....10 Hours

Outcome: Connect and analyze the relationships between voltages and currents in delta-connected circuits.

1. Describe the voltage and current relationships for balanced and unbalanced circuits.
2. Draw a phasor diagram for balanced and unbalanced circuits.
3. Calculate the power factor for balanced and unbalanced circuits.
4. Calculate the true power consumed for balanced and unbalanced circuits.
5. Calculate the reactive power consumed for balanced and unbalanced circuits.
6. Calculate the apparent power consumed for balanced and unbalanced circuits.
7. Draw a power triangle for balanced and unbalanced circuits.
8. Measure voltage, current and phase angle in balanced and unbalanced three phase three wire circuits.

G. Three Phase Power Measurement.....8 Hours

Outcome: Describe and draw the connections for three phase metering and calculate meter readings.

1. Explain power measurement using three wattmeters for balanced and unbalanced circuits.
2. Draw phasor diagram indicating the electrical quantities applied to each wattmeter for balanced and unbalanced circuits.
3. Describe Blondel's theorem.
4. Explain power measurement using two wattmeters.
5. Draw phasor diagrams indicating the electrical quantities applied to each wattmeter for balanced and unbalanced circuits.
6. Perform Delta-Wye/Wye Delta transformation calculations.
7. Connect wattmeters to measure power in a three phase four wire balanced and unbalanced circuits.
8. Connect wattmeters to measure power in a three phase, three wire balanced and unbalanced circuits.

H. Power Factor Correction ..... 5 Hours

Outcome: ***Describe power factor correction and the methods of improving power factor for a circuit.***

1. Define power factor as it applies to a three phase system.
2. Explain how capacitors will correct the power factor of a circuit.
3. Determine how capacitors should be connected to a three phase system for power factor correction.
4. Perform and verify power factor correction calculations.
5. Explain how capacitors can be safely connected to and disconnected from a circuit.
6. Correct power factor in three phase circuits using wye and delta connected capacitor banks.

SECTION TWO: ..... MACHINE THEORY ..... 70 HOURS

A. Transformers ..... 4 Hours

Outcome: ***Describe why transformers are used in different applications.***

1. List the basic features and describe the construction of a single winding transformer.
2. Determine the transformation ratio and volts-per-turn value of a single phase transformer.
3. Describe basic transformer operation.

B. Transformer Ratio, Polarity and Multiple Winding..... 12 Hours

Outcome: ***Analyze transformers in terms of their ratings, ratios, windings and polarities.***

1. Calculate the ratings, ratios and associated values of a single phase transformer.
2. State how transformer voltage taps are used.
3. Describe transformer polarities.
4. Describe a multiple winding transformer.
5. Describe the connection options for a multiple winding transformer.
6. List the items to be checked and hazards involved in connecting and energizing transformers.
7. Verify by measurement the turns ratio and winding resistance on single phase transformers.
8. Measure voltages and currents to verify calculated load values.
9. Identify the terminals of a dual winding transformer and check its polarity.

C. Transformer Losses, Impedance Voltage and Paralleling ..... 10 Hours

Outcome: ***Describe the requirements for paralleling single phase transformers.***

1. Describe transformer losses.
2. Explain what tests are used to determine transformer losses.
3. Describe the requirements for and hazards of paralleling single phase transformers.
4. Define and explain the purpose of %IZ on the nameplate.
5. Calculate the efficiency and the available short-circuit current of a transformer.
6. Connect two transformers in parallel and check how they share the load.

7. Measure transformer losses and calculate efficiency of single phase transformers.
8. From the short-circuit tests, determine the maximum fault current for that transformer.
9. Determine the voltage regulation of single phase transformers.

D. Three Phase Transformers.....20 Hours

Outcome: Describe connections and characteristics of three phase transformers.

1. Explain voltage, current and power relationships in all commonly used three phase transformer connections.
2. Determine the expected voltages and currents with the use of a phasor diagram.
3. Describe the common transformer ratings and the purpose of nameplate data.
4. Explain and calculate the ratio of transformation.
5. Determine rated and load values for line and phase currents and voltages for any transformer connection.
6. Define and determine angular displacement for any transformer bank.
7. Explain the operation and connection of two three phase transformers in parallel.
8. Compare phase and line voltage values to turns ratio of each transformer connection.
9. Connect common transformer configurations.
10. Connect two three phase banks in parallel to feed a common load.
11. Measure angular displacement of three phase transformer banks.

E. Single Phase Motors.....6 Hours

Outcome: Describe the principles of operation, types and applications of single phase motors.

1. Explain the general construction and common types of single phase motors.
2. Explain the theory of operation of single phase motors.
3. Describe how torque is developed in single phase motors.
4. Explain the operation of the starting centrifugal operated switch.
5. Describe the effects of over and under voltage on single phase motors.
6. Identify the windings of a common single phase motor:
7. Connect the motor to a source of voltage for which it is designed to operate.
8. Reverse the direction of rotation on single phase motors.

F. Three Phase Induction Motors.....14 Hours

Outcome: Describe the theory of operation of three phase induction motors.

1. List the main types of three phase motors.
2. State the functions of the principle parts of the squirrel cage induction motor, including:
   a) stator windings
   b) rotor
   c) end bells and bearings
   d) frame
3. Explain the principle of operation of an induction three phase motor.

4. Explain speed regulation and machine efficiency.
5. Describe the effect of full voltage starting on circuits, load and motor and explain operation of common motor starters.
6. Describe methods for reversing three phase motors.
7. Describe the effects of motor over and under voltage.
8. Identify the windings of a common three phase motor.
9. Connect the motor to a source of voltage for which it is designed to operate.
10. Reverse the direction of rotation on three phase motors with and without reversing magnetics.

G. dc Motors ..... 4 Hours

Outcome: ***Describe the theory of operation of dc motors.***

1. Explain the different types of construction for dc motors.
2. Draw a correctly labelled diagram of each type of dc motor.
3. Explain the operation of each of the following dc motors:
   a) Series
   b) Shunt
   c) Compound

SECTION THREE: ..... INTRODUCTION TO SUBSTATION THEORY ..... 114 HOURS

A. Power Transformer (Part 1) ..... 8 Hours

Outcome: ***Describe the basic components and operating features of power transformers.***

1. Identify and describe transformer nameplate data and its function.
2. Identify and describe core construction, losses, grounding and testing.
3. Identify and describe external transformer components.
4. Identify and describe cooling methods and insulating mediums.
5. Identify and describe transformer protective devices.
6. Describe on-load and off-load tap changers.
7. Draw schematic diagrams of three phase wye delta and delta-wye transformer banks connected according to American National Standard Institute (ANSI) standards.

B. Power Transformer (Part 2) ..... 16 Hours

Outcome: ***Demonstrate the testing procedures and troubleshooting skills used on power transformers.***

1. Describe gas and oil sampling and testing and online monitoring.
2. Identify and describe methods of transformer electrical testing.
3. Describe harmonics and their effect on electrical systems.
4. Describe troubleshooting transformer failures.
5. Describe methods of drying out transformers.
6. Describe sweep frequency response analysis.
7. Explain infrared testing and thermal imaging.

8. Determine hot spots on energized current carrying equipment using infrared and thermal imaging test equipment.
9. Measure and calculate humidity and dew point using electronic testers.
10. Measure the ratios and phase angle of a single and three phase transformer.
11. Perform a capacitance and dissipation factor bridge test on a transformer according to manufacturer's operating instructions.
12. Make a comparison to previous test using conversion factors for temperature.
13. Measure the insulation di-electric of a transformer or circuit breaker with a dc hypot, megger and power factor insulation tester.
14. Draw an oil sample and test for di-electric breakdown, neutralization value, interfacial tension and colour.
15. Describe and record wave forms of output voltage and excitation currents with and without a tertiary winding (at various voltage levels) for a transformer.

C. Autotransformers ..... 10 Hours

Outcome: ***Analyze the operation of an autotransformer.***

1. Describe the operation of autotransformers.
2. List the advantages and disadvantages of autotransformers.
3. Perform calculations related to the operation of an autotransformer.
4. Calculate transformed kVA and output kVA.
5. Determine the current rating of series and common windings.
6. Calculate the rated load that could be supplied by autotransformers connected in wye.
7. Connect single and three phase autotransformers to verify calculations.

D. Voltage Regulators ..... 10 Hours

Outcome: ***Describe the operating principles of various voltage regulators.***

1. Explain the applications of voltage regulation in a power system.
2. Describe the different types of voltage regulation methods.
3. Identify the different parts of a step voltage regulator.
4. Describe the different types of step voltage changers.
5. Identify the maintenance procedures for a step voltage regulator.
6. Explain how to operate, switch and test a step voltage regulator.
7. Describe the operation of a sequenced and non-sequenced bypass switch.
8. Connect voltage regulating equipment.
9. Verify the operation and change in voltage when load is varied.

E. Power Circuit Breakers (Part 1) ..... 14 Hours

Outcome: ***Describe power circuit breaker characteristics and associated equipment.***

1. Explain and describe the physical characteristics of power circuit breakers.
2. Identify and describe common types of power circuit breakers, components and the advantages and disadvantages of each type.

3. Describe metal clad and metal enclosed switch gear enclosures.
4. Describe Gas Insulated Systems (GIS), hazards and environmental regulations.
5. Describe point on wave circuit breakers.
6. Identify common applications for each type of circuit breaker.

F. Power Circuit Breakers (Part 2) ..... 10 Hours

Outcome: Describe power circuit breaker characteristics and associated equipment.

1. Explain and describe a typical control schematic associated with circuit breakers.
2. Explain trip free operation.
3. Explain the various breaker characteristics that can be determined from an analyzer chart and breaker timers.
4. Explain contact resistance and erosion.
5. Measure the contact resistance of a circuit breaker and switch.

G. Transmission Line ..... 3 Hours

Outcome: Explain voltage regulation on and efficiency of transmission lines.

1. Explain the voltage regulation of a transmission line from no load to full including the effects of power factor.
2. Explain charging current.
3. Explain the factors affecting the transmission line efficiency in ac and dc lines.

H. Lightning and Surge Protection ..... 3 Hours

Outcome: Explain the different types of lightning and protective equipment.

1. Explain the formation of and different types of lightning.
2. Explain the generation, the properties and the effects of switching surges in a power system.
3. Describe the types of lightning protective equipment including power line shields.
4. Describe the placement and grounding of lightning arrestors in a power system.
5. List the voltage ratings, classifications and monitoring of lightning arrestors.
6. Explain the type of tests and maintenance required for lightning arrestors.

I. Capacitors and Capacitor Banks ..... 4 Hours

Outcome: Explain the use of capacitors in power systems.

1. Describe the construction, insulating medium and rating of capacitors.
2. Explain and calculate how capacitor banks are connected to obtain desired kVAR and kVA for power factor correction and desired voltage.
3. Describe the grounding of capacitors and capacitor banks.
4. Describe the fusing and protection for capacitors and banks.
5. Describe the generation of transient voltages and currents due to the switching of capacitors.
6. Explain the ratings required by switches and circuit breakers.
7. Explain the operation of a static shunt compensator (static var system).

J. Reactors ..... 1 Hour

Outcome: ***Explain the use of reactors in power systems.***

1. Identify the applications of reactors in power systems.
2. Explain the application of shunt and series reactors.

K. Generators ..... 8 Hours

Outcome: ***Describe the basic construction and theory of operation of a generator.***

1. Describe the function, operation and connection of a generator stator and rotor.
2. Explain the principles of EMF induction.
3. Describe the characteristics and parameters associated with speed, poles and frequency.
4. Explain generator output voltage, waveform and voltage regulation.
5. Explain loading curves and overload capacity.
6. Describe shifting kW and kVAR load.
7. Describe generator excitation methods.
8. Connect a three phase generator and study its characteristics under lagging and leading load conditions.

L. Paralleling Generators ..... 10 Hours

Outcome: ***Describe the basic theory and methods of paralleling generators.***

1. Describe and explain operation of conditions for and methods of parallel operation.
2. Describe a standby unit, switching procedures required and hazards of backfeed.
3. Explain basic generator testing.
4. Explain the principles of and hazards involved with co-generation.
5. Explain the principles of load shedding and islanding.
6. Parallel three phase generators.

M. Synchronous Motor ..... 1 Hour

Outcome: ***Describe the basic operation of a synchronous motor.***

1. List the components of a synchronous motor.
2. Explain the principal of operation when used as a motor and for power factor correction.

N. Substation Batteries ..... 4 Hours

Outcome: ***Describe substation batteries, testing and applications.***

1. Identify the types of batteries and ratings associated with substation battery banks.
2. Describe the hazards, applications and precautions associated with different types of substation battery banks.
3. Explain and describe maintenance, testing and charging procedures for substation battery banks.
4. Perform battery impendence tests.

O. Grounding ..... 10 Hours

Outcome: Describe system grounding, equipment grounding and gradient control.

1. Explain the reasons and rationale for grounding.
2. Describe the types of hazards including earth gradients that may occur during a fault condition.
3. Explain and describe factors affecting system grounds in different electrical systems.
4. Explain and describe ungrounded systems and the factors affecting them.
5. Explain how a ground source is provided in zigzag and wye-delta configurations.
6. Explain the methods used for the detection of ground faults in ungrounded systems.
7. Describe equipment grounding and the factors affecting it.
8. Explain static grounding and the factors affecting it.
9. Explain the function of and factors affecting a grounding system.
10. Explain the reasons for surface gradient control.
11. Describe how grid conductor, grounding conductor and connectors are selected.
12. Explain how the maximum ground fault current is determined.
13. Describe how to measure the resistance of a ground rod and the resistivity of the substation grid.
14. State the guidelines for grounding substation fences.
15. Explain the hazards associated with overhead shielded wires, underground cables and repairing of static ground grids.
16. Measure the ground resistance of a ground electrode with test equipment.

P. Insulators ..... 2 Hour

Outcome: Describe insulators used in power systems.

1. Explain and describe insulator types, materials and mechanical characteristics.
2. Define basic impulse level (BIL), flash over, leakage current, and dielectric strength.

SECTION FOUR: ..... ELECTRONICS THEORY ..... 40 HOURS

Electronics Introduction ..... 10 Hours

Outcome: Describe the characteristics of fundamental electronic circuit components.

1. Identify and calculate basic voltage conversions, waveforms, notations for electronic circuits.
2. Explain the electrical properties and ratings of resistors in series and parallel.
3. Explain the electrical properties and ratings of inductors in series and parallel.
4. Explain the electrical properties and ratings of capacitors in series and parallel.
5. Demonstrate proper use of common test instruments used in electronic circuits.

B. PN Junction (Diode) ..... 4 Hours

Outcome: Describe the principles of operation and the applications of PN junction diodes.

1. Describe the PN junction characteristics, symbol and ratings.
2. Identify the diode terminals and ratings from a specification sheet.

3. Describe test procedures for a diode using various testing instruments.
4. Verify diode ratings and terminal identification using a specification sheet.
5. Test the diode condition using various measuring instruments.

C. Rectifiers ..... 10 Hours

Outcome: Describe rectifier circuits and characteristics.

1. Describe common types of half, full wave, single phase, three phase and six phase rectifier circuits.
2. State the diode ratings and draw the waveform associated with each rectifier.
3. Calculate the average dc value of voltage for each rectifier.
4. Describe the methods and materials used for heat sinking and isolating diodes in rectifier circuits.
5. Construct single and three phase rectifiers.
6. Measure single and three phase rectifier waveforms.
7. Measure single and three phase rectifier average dc voltage values.

D. Filters ..... 6 Hours

Outcome: Describe the characteristics and use of filter circuits.

1. State the need and components for filters on rectifier circuits.
2. Draw the output waveform for a capacitor filter circuit.
3. Define and calculate the ripple factor for a filtered output.
4. Determine the voltage regulation of a filtered output.
5. Construct a filter circuit.
6. Measure the ripple voltage from a rectified filtered output.
7. Measure the voltage regulation of the filter circuit.

E. Silicon Controlled Rectifier (SCR) ..... 2 Hours

Outcome: Describe basic operation and characteristics of SCR's.

1. Explain the operation of an SCR.
2. State the ratings and analyze the operation of an SCR in a circuit.
3. Describe common applications for SCR's and any special utility applications.

F. Application of Diodes and Rectifiers ..... 8 Hours

Outcome: Describe rectifier components in a battery charger and some applications of diodes.

1. Describe the practical aspects and typical applications of diodes.
2. Select replacement rectifier components including diodes, heat sinks and filter capacitors from manufacturer's specification sheets.
3. Describe the operation of and troubleshoot the rectifier stage of a battery charger.
4. Connect and troubleshoot a circuit that includes a rectifier or SCR used in a battery charger.

SECTION FIVE: ..... PRINT READING ..... 30 HOURS

A. Applied Print Interpretation..... 16 Hours

Outcome: ***Read and interpret information from a drawing or print.***

1. Demonstrate a familiarity with parts lists, legends, symbols, abbreviations and IEEE device numbers from prints.
2. State the purpose of specifications and the use of standards.
3. Explain trade related information from a set of structural drawings of a substation.
4. Explain trade related information from a set of electrical prints of a substation.
5. Identify all equipment connected to each phase on a single line drawing.
6. Identify all equipment connected to each phase on a three phase drawing.
7. Identify primary, secondary and tertiary windings and their respective voltages on a single line drawing.
8. Identify current and potential transformers and their connections to metering and protection devices on a single line drawing.
9. Given a schematic diagram, identify the various electrical devices.
10. Given a schematic diagram, describe the interaction of all the devices.

B. Troubleshooting Electrical Circuits ..... 14 Hours

Outcome: ***Using station drawings and schematics demonstrate an organized approach to troubleshooting.***

1. Verify electrical prints to field wiring, devices and connections.
2. Utilize schematics and wiring diagrams in troubleshooting circuits.
3. Demonstrate basic troubleshooting techniques.
4. Troubleshoot typical control circuits associated with breakers.

FOURTH PERIOD TECHNICAL TRAINING
POWER SYSTEM ELECTRICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: .....METERING THEORY ..... 100 HOURS

A. Instruments ..... 7 Hours

Outcome: ***Explain the characteristics of fundamental metering instruments.***

1. Identify and describe common types of metering instrument movements and limitations of permanent magnet, moving iron vane and electronic meters.
2. Explain and compare the accuracy of analog and electronic meters.
3. Explain the methods used to increase the range of a voltmeter and of an ammeter.
4. Explain the effects of meter loading and circuit loading.
5. Describe the basic operation and installation of recording meters.

B. Watt-hour Meters ..... 6 Hours

Outcome: ***Explain the characteristics and operation of watt-hour meters.***

1. Explain and describe the theory and operation of induction type watt-hour meters.
2. Explain why watt-hour meters have built in voltage, temperature and power factor correction compensators.
3. Explain how Kh, Rg and Rr meter constants are developed and state the formula used for a watt-hour meter.
4. Explain how the watts of the connected load can be determined by timing the meter disk.
5. Explain under what conditions that full load, light load and lag tests are performed and describe what parts of the meter are adjusted to improve the meter accuracy.
6. Interpret meter readings on a dial register.
7. Explain how shop and field tests are performed.

C. Single Phase Meter Connections ..... 14 Hours

Outcome: ***Describe various common meter and instrument transformer connections in single phase systems using formula and phasor diagrams.***

1. Review two and three wire meter connections.
2. Explain the operation of a three-wire CT meter connection on a three wire circuit.
3. Describe the two CT method of metering a three wire circuit using a two wire watt-hour meter.
4. Explain the operation of a network watt-hour meter.
5. Describe how a single phase watt-hour meter is connected to measure varhours.
6. Describe the basic concept of varhour metering using a standard watt-hour meter and a voltage network supply.
7. Explain metering connections by using formulae and phasor diagrams.

8. Connect and verify a three wire current transformer to properly measure the energy of a three wire, single phase load using a two wire kWh meter.
9. Connect and verify the connection of 2 current transformers to properly measure the energy of a three wire single phase load using a two wire kWh meter.
10. Connect and verify the results of a network kWh meter used to properly measure the energy of a three wire circuit feed from a wye supply.
11. Determine and verify the billing multiplier for a metering point that uses CT's in the circuit.
12. Explain and check the results of incorrect primary or secondary polarity connections on the preceding CT connections.

D. Three Phase Meter Connections ..... 14 Hours

Outcome: ***Describe various common meter connections in three phase systems using formula and phasor diagrams.***

1. Explain three phase self-contained watt-hour meter connections for two, two and half and three element meters for wye and delta systems.
2. Explain metering connections by using formulae and phasor diagrams.
3. Connect and verify a two element kWh meter feed from a three phase delta supply.
4. Install and verify a $2^1/_2$ element kWh meter for wye-four wire supply.
5. Install and verify a $2^1/_2$ element kWh meter for delta-four wire supply.

E. Demand Meters ..... 10 Hours

Outome: ***Describe various demand meter connections using formula and phasor diagrams.***

1. Define "demand meter" and describe their importance to a Utility.
2. Identify and explain thermal, block, sliding window and electronic demand meters for kVA or kW measurement.
3. Explain the procedure used in the field to reset demand meters, how this procedure may vary between Utilities and how the demand part of this meter can be damaged.
4. Describe how the demand value is used and basic consumption is determined in billing.
5. Define and describe "kVA demand" using arithmetic and phasor additions.
6. Explain how kVA demand elements convert kWh to kVA demand.
7. Explain why the maximum demand of meter is different than calculated maximum on unbalanced loads.
8. Connect a polyphase kW demand meter to measure the demand on 3 and 4 wire loads.
9. Verify meter demand readings by measuring current, voltage and power factor.
10. Plot demand over time and compare maximum actual to load.
11. Connect a polyphase kVA demand meter to measure the demand of a 3 and 4 wire load.
12. Verify meter demand readings by measuring current, voltage of both.

F. Polyphase Meters (Instruments Transformers) ..... 16 Hours

Outcome: ***Describe various polyphase meters and instrument transformer connections using formula and phasor diagrams.***

1. State and verify using phasor diagrams the correct formula of voltage and current used by each meter to register the correct consumption of energy used.
2. Identify the correct polarity of VT’s and CT’s to supply energy to the meter.

3. Explain the effect of loss of potential conditions on the meter.
4. Describe how to perform a load check to verify the accuracy of a connected meter.
5. Describe and explain the function, operation and hazards of test switches.
6. Describe the standard colour code outlined by Measurement Canada for the wiring between the test switch and meter.
7. Explain, describe and verify using formula and phasors how delta connected CT's can be used with a two element meter.
8. List possible reasons for changing revenue meters and describe the steps that should be taken to verify the metering point after the meter has been changed.
9. Connect and verify three phase, three wire, 2 element meter with CT and VT's.
10. Connect and verify three phase wye or delta, four wire with CT and VT's:
11. Verify polyphase instrument rated meter installation for colour codes, connections, grounding and consumption.

G. Metering Transducers ..... 6 Hours

Outcome: ***Describe various transducers used for power measurement.***

1. Explain and calculate the input and output ratings of transducers from nameplate data.
2. Describe how the output of a transducer can be changed from current to voltage outputs.
3. Explain the "Hall effect" transducer and its general use today.
4. Connect output of transducer to dc ammeter and determine input amount.
5. Connect transducer outputs to totalize two feeders.

H. Metering, Totalizing and Recording ..... 12 Hours

Outcome: ***Describe various analog and digital metering, totalizing and recording methods for power measurement.***

1. Describe briefly how analog to pulse converters operate and list two methods of conversion.
2. Explain how auxiliary pulses are produced and describe why they may be required at a metering location.
3. Describe general methods used for sending pulses from metering point to the recorder and how pulse values are calculated.
4. Explain what happens if storage capacity has been exceeded on electronic recorders and how stored information can be retrieved.
5. Explain the advantages of electronic pulse initiators over the mechanical type of initiators.
6. Describe the general principle and explain the advantages of electronic totalization over mechanical totalization.
7. Connect polyphase meters with pulse initiation to recorders to accumulate pulses.
8. Verify results of metering to be correct from pulses and Ki values.
9. Calculate the watt-hours per pulse (Ki) of pulse initiators using the kh of meter nameplate and pulses per disk revolution.

I. Safety In Changing Meters ..... 4 Hours

Outcome: ***Describe safety procedures with meter installations.***

1. List hazards and explain proper procedures when installing or removing a self contained meter at a new or existing location.

2. List hazards and explain proper procedures when installing or removing instrument rated meters.
3. Properly verify all self contained meter connections at the socket and at the terminals of a bottom connected meter by voltage and visual checks.
4. Demonstrate how a connected meter can be verified by checking voltage, current, power factor of load and timing meter disk.

J. Telemetering and Automated Metering Infrastructure (AMI) ..... 4 Hours

Outcome: Describe telemetering and automated infrastructure methods for data acquisition.

1. Explain how it's possible to verify a metering point when using computerized metering equipment.
2. Describe the physical connections required between computer, cell phone and meter or recorder.
3. Describe what information is possible to obtain with these methods of metering.

K. Regulatory Agencies ..... 4 Hours

Outcome: Describe government and non-government regulatory agencies and the role they play in power measurement.

1. State the basic standards for polarity marks and wire color code for secondary conductor connections on instrument transformers for revenue metering.
2. Explain what accuracy range is acceptable and how regulatory agencies test and verify revenue meter installations.
3. Describe what is meant by "seal extension" and what is required by Measurement Canada.
4. Describe what is meant by dispute testing and explain how a dispute test with a customer is performed.
5. Explain what regulations effect revenue metering and how Measurement Canada controls and approves metering equipment.
6. Describe the roles of the regulatory bodies in Alberta associated with transmission and power distribution.

L. Detection and Prevention of Energy Theft ..... 3 Hours

Outcome: Describe methods of detection and prevention of energy theft and diversion.

1. Explain what seals are installed at a metering point by the Utility and Measurement Canada and the importance of sealing programs in the prevention of energy theft.
2. Explain how internal tampering can be done to electro-mechanical meters and describe what safeguards exist to prevent this.
3. Describe how energy diversion can be performed internal or external to the meter.
4. Explain what action an employee should take in reporting a case of energy theft.

SECTION TWO: ..... SUBSTATION THEORY ..... 146 HOURS

A. Potential Transformers ..... 8 Hours

Outcome: Describe potential transformers including operation, ratings, polarity and accuracy.

1. Describe the operation of potential transformers.
2. Describe types of potential transformers.
3. Describe ratings and accuracy of potential transformers.

4. Explain potential transformer polarity.
5. Explain potential transformer test procedures.
6. Describe potential transformer connections.
7. Perform ratio and insulation tests on a potential transformer.
8. Verify polarity marks by open circuit ac method and inductive kick method.
9. Connect and provide proper protection for potential transformers.

B. Current Transformers ..... 8 Hours

Outcome: ***Describe current transformers including operation, ratings, polarity and accuracy.***

1. Describe the operation of current transformers.
2. Describe types of current transformers.
3. Describe ratings and accuracy of current transformers.
4. Explain current transformer polarity.
5. Explain current transformer test procedures.
6. Describe current transformer connections.
7. Describe metering tanks.
8. Perform saturation, ratio and insulation tests on a current transformer.
9. Explain and demonstrate the proper method of de-magnetizing a current transformer.
10. Verify polarity marks by open circuit ac method and inductive kick method.
11. Connect different types of current transformers.

C. Power Systems ..... 2 Hours

Outcome: ***Describe the Alberta transmission and distribution systems and how it relates to other jurisdictions.***

1. Identify and describe common types and functions of power systems in generation including co-gen.
2. Identify and describe the Alberta Electrical Integrated System. (AEIS)
3. Identify and describe common types of distribution systems including overhead, underground and network.

D. Bus Configurations ..... 3 Hours

Outcome: ***Describe different bus configurations.***

1. Explain and describe the single, transfer, double and ring bus switching systems.
2. Explain and describe breaker and one-half and breaker and one third.

E. Switching Equipment ..... 5 Hours

Outcome: ***Describe switching equipment.***

1. Identify the types and applications of high voltage air, fused and bypass disconnect switches.
2. Explain the operation of a motor controlled switch.
3. Describe the methods used for arc interruption.
4. Describe the ratings of various types of interrupters.

F. System Fault Current.....20 Hours

Outcome: Describe system fault current.

1. Identify and describe fault currents including sources, symmetrical/asymmetrical, dc component, X/R ratio and mechanical and thermal stress.
2. Calculate and explain single phasing, open delta and loss of power on the secondaries of various 3 phase transformer connections when primary fuse failure occurs.
3. Calculate wye connected VT secondary voltages on grounded and ungrounded systems.
4. Define the sub transient, transient and synchronous reactance.
5. Explain and calculate the per unit method used in short circuit calculations to determine fault current of line-line-line, line-line and line to ground faults.
6. Calculate circuit impedance using delta-wye and wye-delta transformations.
7. Identify and describe applications for choosing breaker ratings (thermal capacity I^2t), bus rating, relay setting and fuse size from calculated fault levels.
8. Simulate fuse failures on the primary side of three phase transformer banks (wye, grounded wye, and delta) and then analyze the secondary voltages.
9. Simulate the per-unit fault current of a line-line-line, line-line and line to ground faults.
10. Determine the secondary potential transformer voltages that will exist in a grounded and ungrounded system using potential transformers.
11. Observe a simulated supply network, and compare calculated values of short circuit fault MVA to measured values.
12. Observe faults on a radial system.

G. Symmetrical Components.....6 Hours

Outcome: Describe symmetrical components of three phase circuits.

1. Define and calculate the positive, negative and zero sequence components for balanced and unbalanced conditions.
2. Calculate fault currents using symmetrical impedances.
3. Calculate relay settings for current unbalance using I_1 and I_2.
4. Determine the positive, negative and zero sequence voltages in a “floating” neutral circuit using the system neutral as a reference.
5. Determine positive and negative sequence currents in an unbalanced three phase load.
6. Draw phasors of the sequence components to show that their sum is equal to the measured currents.
7. Calculate the % unbalance of currents using I_1 and I_2.

H. Relaying .....2 Hours

Outcome: Describe protective relay types and construction.

1. Describe protective relay types, design and classifications.
2. Define IEEE device numbers for relay designations.

I. Relaying Systems .....5 Hours

Outcome: Describe electrical protection circuits and relaying schemes.

1. Explain and describe function and operation of primary and back up protection relay systems.

2. Identify and describe zones of protection using single line and ac elementary diagrams.
3. Identify and describe common channel types including pilot wire, fibre optic and microwave.
4. Identify and describe common relaying schemes.

J. Overcurrent Protection.....24 Hours

Outcome: Describe overcurrent protection.

1. Identify and describe phase and ground protection.
2. Explain and describe overcurrent characteristic curves.
3. Explain and describe overcurrent protection connection in a circuit.
4. Explain and describe clearing times for overcurrent protection.
5. Coordinate relays on a radial system using CT's, relay curves and time dial settings.
6. Using a microprocessor based relay and computer apply and explain the functions including overcurrent protection, automatic reclosure, sequence coordination and breaker interrupting duty.
7. Describe the operation and parts of electro-mechanical overcurrent relays.
8. Test electro-mechanical and electronic relays.
9. Compare the differences and accuracy of electro-mechanical and electronic relays.
10. Demonstrate coordination between two overcurrent relays.
11. Analyze relay human-machine interface (HMI), current, demand values, fault reports and disturbance data.

K. Directional Protection.....14 Hours

Outcome: Describe directional protection.

1. Explain and describe the theory of operation of directional relays.
2. Explain and describe the application and selection of actuating quantities for power directional relays.
3. Explain and describe the application and selection of actuating quantities for current directional relays.
4. Explain the differences in the applications and connections for phase directional, ground directional and power directional relays.
5. Test an overcurrent directional relay.
6. Given a single line diagram, draw a three phase ac elementary diagram and connect and operate a directional power relay.

L. Differential Protection .....10 Hours

Outcome: Describe differential protection.

1. Identify and describe the theory of differential protection and their applications.
2. Correct CT connections on wye-delta transformer primary and secondary, relay taps and define % mismatch.
3. Identify and describe generator, transformer, bus and line differential protection.
4. Perform a pick-up, through fault and slope test on differential relays.
5. Interpret manufacturers' curves for various % slope differential relays.

M. Impedance Protection ..... 5 Hours

Outcome: Describe impedance protection.

1. Explain and describe the theory of operation of an impedance relay.
2. Explain distance relay characteristics on the R-X diagram.
3. Explain and describe under-reach and over-reach transfer tripping schemes.
4. Explain and describe quadrature zones of protection.

N. Reclosing Relays ..... 6 Hours

Outcome: Connect, test and verify reclosing relays.

1. Describe the purpose of reclosing relays.
2. Demonstrate the principles and purposes of auto reclosing.
3. Set an auto recloser to perform various reclosing sequences and observe breaker operation.

O. Synchronism Check Relay ..... 1 Hour

Outcome: Describe synchronism check relay.

1. Explain the purpose and connection of synchronism check relay.

P. Frequency Protection ..... 1 Hour

Outcome: Describe frequency protection.

1. Explain and describe the theory of operation of a frequency relay.
2. Identify and describe application of frequency relays.

Q. Network Protection ..... 1 Hour

Outcome: Describe network protection.

1. Explain and describe the theory of operation of a network protection scheme.

R. Microprocessors and Logic Relay Functions ..... 16 Hours

Outcome: Describe microprocessor and logic relay functions.

1. Compare digital to analog devices and signals.
2. Describe the common underlying principles of different number systems.
3. Explain the purpose of logic gates.
4. Show the truth tables and Boolean equation for the common logic gates.
5. Describe various types of read-only and read-write memories and their applications.
6. Discuss the differences of static and dynamic read-write memory devices.
7. Describe the purpose and function of the micro processing unit.
8. Set various protection parameters on the micro-processor relay using a keypad interface.
9. View current and demand values on a relay keypad interface.
10. Set various protection parameters on the computer and down load them to the relay.
11. View relay current and demand values on the computer.
12. Connect the micro-processor based relay to a simulated circuit and observe operation of the relay, breaker and recloser under various fault conditions.

13. Access and save fault reports via the computer.
14. Save the disturbance data to a file.
15. Plot the relay demand data, breaker interrupting duty (I^2t) and disturbance data using the relay software and computer printer.

S. Breaker Failure Protection ..... 1 Hour

Outcome: Describe breaker failure protection.

1. Explain and describe the theory of operation of a breaker failure relay scheme.

T. Supervisory Control And Data Acquisition (SCADA) ..... 4 Hours

Outcome: Describe Supervisory Control and Data Acquisition (SCADA).

1. Explain and describe the purpose and function of Supervisory Control and Data Acquisition (SCADA).
2. Explain and describe the various communication methods used in SCADA.

U. Precommissioning and Commissioning of Substation ..... 3 Hours

Outcome: Describe substation commissioning procedures.

1. Describe the importance of receiving, cataloguing and acceptance testing new equipment.
2. Identify the prints, standards and specifications required and explain the importance of as-built drawings.
3. Explain the requirement of installation, function, energization and in service checks.

V. Maintenance Programs ..... 1 Hour

Outcome: Describe proper maintenance programs.

1. Discuss benefits of scheduled inspection and test programs.
2. Explain general maintenance requirements.

SECTION THREE: ELECTRICAL CODE AND SAFETY AND WORKPLACE COACHING SKILLS .... 54 HOURS

A. Workplace Coaching Skills / Mentoring .....6 Hours

Outcome: ***Describe the role of the journeyman tradesmen, employers, the Provincial Apprenticeship Committee and Alberta Apprenticeship and Industry Training in the development and maintenance of the Power System Electrician trade in Alberta.***

1. Review the terms of apprenticeship and describe the advancement criteria for an apprentice within the Power System Electrician trade.
2. Explain and describe the purpose of the apprentice record book role for apprentice and employer in competency task check-off requirements and updating procedures.
3. Describe and demonstrate the coaching skills used for training apprentices.

B. Alberta Electrical Utility Code (AEUC).....17 Hours

Outcome: ***Understand why and how the AEUC is used to provide minimum standards for utility electrical installations in the province and know who is responsible for utility electrical installations.***

1. Locate and use the definitions to interpret the AEUC.
2. Locate and interpret the rules in Section 2, 6, 8 and Appendix A.
3. Describe procedures to obtain authorization to perform operations or work.
4. State the safe limits of approach for persons and equipment working near lines.
5. State the safe limits of approach distances and explain how they apply to the work of the power system electrician.
6. Give a typical work situation and be able to identify applicable AEUC rules.

C. Personal Protective Equipment.....6 Hours

Outcome: ***Describe the use and care of specialized personnel protective equipment.***

1. Describe the proper care, maintenance and storage of protective rubber gloves, sleeves, live line tools and live line cover-up.
2. Illustrate the daily inspection of protective rubber gloves, live line cover-up and live line tools.
3. Describe the visual and di-electric testing of protective rubber gloves, sleeves, live line tools and cover-up.
4. List the applications of commonly used hot sticks and accessories.
5. Describe arc flash hazards and safety equipment related to it.

D. Rigging.....5 Hours

Outcome: ***Describe basic rigging procedures.***

1. Describe the effect that sling angles have on safe lifting.
2. Identify the load limits of commonly used wire rope slings and synthetic slings.
3. Describe the causes and effects of shock loading on rigging.
4. Identify OHS regulations regarding rigging safety factors.

E. Protective Working Grounds ..... 7 Hours

Outcome: ***Describe personal protective grounds.***

1. List the types of hazards that personal protective grounds guard against.
2. List the electrical and mechanical requirements of a personal protective ground.
3. Describe and understand the principle and requirements of equi-potential grounding.
4. Outline the procedure of installing and removing personal protective grounds.
5. Outline the procedure for installing and removing equi-potential grounds.
6. Explain the required locations of personal protective grounds according to AEUC.
7. Explain the required locations of personal protective grounds when using the equi-potential ground methods.

F. Canadian Electrical Code (CEC) Part I ..... 5 Hours

Outcome: ***Understand why and how the CEC is used to provide minimum standards for electrical installations in the province.***

1. Locate and apply the general requirements pertaining to protective and control devices.
2. Determine when protective and control devices are required and select the proper types and ratings.
3. Locate and apply the rules pertaining to liquid filled equipment, transformers, lightning arrestors and battery rooms.
4. Locate and apply the rules pertaining to the protection and control of generators.

G. Switching Programs / Single Line Diagrams ..... 8 Hours

Outcome: ***Demonstrate the ability read single line diagrams, write switching orders and issue Guarantee of Isolation (GOI) orders.***

1. Review single diagrams and identify isolation points on drawing and on site to isolate equipment.
2. Prepare switching orders to isolate and issue work clearances or re-energize portions of a substation system using a single line diagrams.
3. Explain the requirements of a GOI, working clearance and lock-out / tag-out procedures.

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